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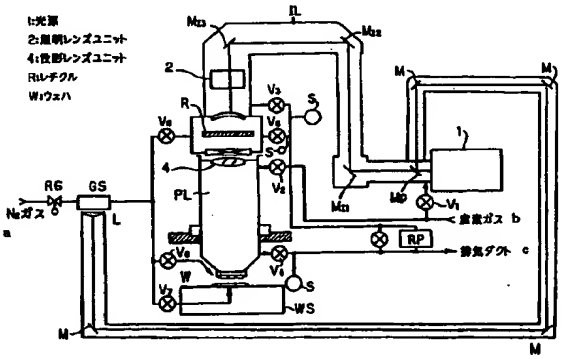
(54)Title: **OPTICAL DEVICE, METHOD OF CLEANING THE SAME, PROJECTION ALIGNER, AND METHOD OF PRODUCING THE SAME**

(54)発明の名称 光学装置、その洗浄方法、投影露光装置及びその製造方法

(57) **Abstract**

A reticle (R) is irradiated with an ArF excimer laser beam to transfer a pattern on the reticle (R) onto a wafer (W) through a projection optical system (PL). Each of a plurality of illuminating lens units (2) arranged in the illuminating optical passage has a lens barrel containing a plurality of lenses, and caps are so provided as to be spaced from the lenses at both ends. Lens chambers among the lenses are filled with an inert gas, and the spaces between the caps and the lenses are also filled with an inert gas. When the illuminating lens units (2) are housed in and illuminating optical path housing, the caps are removed while purging the spaces. Therefore, the lenses at both ends are prevented from being contaminated and the transmittance of the optical lens device for exposure with light having a wavelength of shorter than 300 nm is prevented from lowering.



(57)要約

ＡｒＦエキシマレーザをレチクルＲに照射して、レチクルＲ上のパターンを投影光学系ＰＬを介してウェハW上に転写する。照明光路中に配置された複数の照明レンズユニット２のそれぞれには鏡筒内に複数のレンズを有し、両端のレンズと所定の間隔をあけて蓋が設けられる。各レンズの間のレンズ室には不活性ガスが充填されているとともに、蓋とレンズとの間の空間にも不活性ガスが充填されている。照明レンズユニット２を照明用光路筐体中に設置する際、上記空間をパージしながら蓋を取り外すことにより、両端のレンズが汚染されるのを防止し、波長３００ｎｍ以下の露光光を使用する光学レンズ装置の透過率の劣化を防止する。

明 細 書

光学装置、その洗浄方法、投影露光装置及びその製造方法

発明の属する技術分野

本発明は、たとえば３００ｎｍ以下の紫外域の光を照射するエキシマレーザ、高調波レーザ、水銀ランプ光源を有する露光装置及びその製造方法に関する。また、本発明はこのような露光装置に使用される投影光学系用や照明光学系用の光学装置、および光学装置の洗浄方法に関する。

発明の背景

半導体素子または液晶基板等を製造するためのリソグラフィ工程において、レチクル（フォトマスク等）のパターン像を投影光学系を介して感光基板上に露光する露光装置が使用されている。近年、半導体集積回路は微細化の方向で開発が進み、リソグラフィ工程においては、より微細化を求める手段としてリソグラフィ光源の露光波長を短波長化する方法が考えられている。

現在、波長２４８ｎｍのＫｒＦエキシマレーザをステッパー光源として採用した露光装置がすでに開発されている。また、Ｔｉ－サファイアレーザ等の波長可変レーザの高調波、波長２６６ｎｍのＹＡＧレーザの４倍高調波、波長２１３ｎｍのＹＡＧレーザの５倍高調波、波長２２０ｎｍ近傍または１８４ｎｍの水銀ランプ、波長１９３ｎｍのＡｒＦエキシマレーザ等が短波長光源の候補として注目されている。

従来のｇ線、ｉ線、ＫｒＦエキシマレーザあるいは波長２５０ｎｍ近傍の光を射出する水銀ランプを光源とした露光装置では、これらの光源の発光スペクトル線は酸素の吸収スペクトル領域とは重ならず、酸素の吸収による光利用効率の低下および酸素の吸収によるオゾンの発生に起因する不都合はなかった。したがって、これらの露光装置では基本的に大気雰囲気での露光が可能であった。

しかしながら、ＡｒＦエキシマレーザのような光源では、発光スペクトル線は酸素の吸収スペクトル領域と重なるため、上述の酸素の吸収による光利用効率の低下および酸素の吸収によるオゾンの発生に起因する不都合が発生する。たとえ

ば、真空中または窒素あるいはヘリウムのような不活性ガス中でのＡｒＦエキシマレーザ光の透過率を１００％／ｍとすれば、フリーラン状態（自然発光状態）すなわちＡｒＦ広帯レーザでは約９０％／ｍ、スペクトル幅を狭め、かつ酸素の吸収線を避けたＡｒＦ狭帯レーザを使用した場合でさえ、約９８％／ｍと透過率が低下する。

透過率の低下は、酸素による光の吸収および発生したオゾンの影響によるものと考えられる。オゾンの発生は透過率（光利用効率）に悪影響を及ぼすばかりでなく、光学材料表面や他の部品との反応による装置性能の劣化および環境汚染を引き起こす。

このように、ＡｒＦエキシマレーザのような光源を有する露光装置では、光の透過率の低下やオゾンの発生を回避するために光路全体を窒素等の不活性ガスで満たす必要があることはよく知られている。

ところで本発明者等は、エキシマレーザ光源を用いた比較的フィールドサイズの大きい投影露光装置によって各種の露光実験を行なったところ、例えば３５０ｎｍ以下の紫外波長域の照明光（波長２４８ｎｍのＫｒＦエキシマレーザ、或いは波長１９３ｎｍのＡｒＦエキシマレーザ等）の照射によって、投影光学系内の光学素子、或いは光学素子のコート材（たとえば反射防止膜等の薄膜）の透過率または反射率がダイナミックに変動するといった新たな現象を発見した。このような透過率がダイナミックに変動する現象は、投影光学系内の光学素子のみならず、レチクルを照明する照明光学系、またはクリーンルームの床下に配置される光源から射出される照明光を露光装置本体内の照明光学系に導く送光系内の光学素子やレチクル（石英板）自体についても全く同様に発生し得ることが判明した。

このような現象は、投影光路内や照明光路内の空間に存在する気体（空気、窒素ガス等）中に含まれる不純物、光学素子を鏡筒に固定するための接着剤または充填材等から発生する有機物質の分子、或いはその鏡筒の内壁（反射防止用の塗装面等）から発生する不純物（たとえば水分子、ハイドロカーボンの分子、またはこれら以外の照明光を拡散する物質）が光学素子の表面に付着したり、照明光路内に進入（浮遊）することで生じるものと考えられる。その結果、投影光学系，照明光学系および送光系の透過率または反射率が比較的短時間のうちに大きく変

動するといった重大な問題が起こる。

発明の概要

本発明の目的は、投影光学系，照明光学系や送光系を構成するレンズや反射鏡などの光学素子が汚染されにくい光学装置、その洗浄方法、そのようにして洗浄された汚染されにくい投影光学系あるいは照明光学系または送光系を用いる露光装置及びその製造方法を提供することにある。

さらに、例えば波長３５０ｎｍ以下の放射ビームの照射による光学部材の光学特性（例えば透過率または反射率）の変動を防止できる露光装置を提供することにある。

さらにまた、露光装置に組込まれた照明光学系，投影光学系あるいは送光系などの光学部材を光洗浄できる露光装置を提供することにある。

本発明の光学装置は、内部に複数の光学素子が配置された鏡筒の軸線方向両端に、前記複数の光学素子のうち前記鏡筒の軸線方向両端側に配置された光学素子との間に所定間隔をあけて保護フィルタを配置し、前記複数の光学素子間の室および前記両端側の光学素子と前記保護フィルタとの間の空間に、予め不活性ガスをそれぞれ充填することにより、上記目的を達成する。

前記光学装置は、照明光をマスクに照射し、該マスクを介して該照明光で基板を露光する装置に装備され、前記不活性ガスは、前記照明光の吸収が少ないガスである。また、前記照明光の波長は３５０ｎｍ以下である。また、前記光学装置を前記露光装置に装備された照明光学系の光路筐体中に設置する際に、前記空間を前記ガスでパージしながら前記保護フィルタを取り外すようにし、その後前記光路筐体中に前記ガスを充填するか、あるいは前記光学装置を前記露光装置に装備された照明光学系の光路筐体中に設置する際に、前記空間を前記ガスでパージしながら前記保護フィルタを取り外し、予め洗浄された新たな保護フィルタを前記鏡筒の軸線方向両端に取り付けるようにし、その後前記光路筐体中に前記ガスを充填することが好ましい。

本発明の別の光学装置によれば、複数の光学素子が配設された鏡筒内に不活性ガスを供給する供給通路と、前記供給通路が接続される供給口と、前記鏡筒内の不活性ガスを排出する排出口とを備え、前記供給通路の内壁に汚染物質を除去

する除去部材を設けることにより、上記目的を達成する。

前記光学装置は、照明光をマスクに照射し、該マスクを介して該照明光で基板を露光する装置に装備され、前記不活性ガスは、前記照明光の吸収が少ないガスである。また、前記除去部材としては、吸着材又はフイルタが使用される。

また、本発明の別の光学装置は、マスク上のパターンを基板上に転写する露光装置に用いられる光学装置にして、複数の光学素子が配設された鏡筒の内面に汚染物質の除去部材を設けることにより、上記目的を達成する。

また、本発明の別の光学装置は、照明光をマスクに照射して、該マスク上のパターンを基板上に転写する露光装置に用いられる光学装置にして、鏡筒内に配設された複数の光学素子の間に形成される複数の室のそれぞれに前記照明光の吸収が少ないガスの供給口と排出口を設け、前記供給口と排出口にはそれぞれ開閉弁を設けることにより、上記目的を達成する。

本発明の光洗浄方法は、照明光をマスクに照射して、該マスク上のパターンを基板上に転写する露光装置に用いられる光学装置の洗浄方法にして、前記光学装置を、鏡筒内に配設された複数の光学素子の間に形成される複数の室のそれぞれに前記照明光の吸収が少ないガスの供給口と排出口を設け、前記供給口と排出口にはそれぞれ開閉弁を設けて構成し、前記光学装置を、前記供給口の開閉弁を開く一方、前記排出口の開閉弁を閉じた状態で前記ガスを前記鏡筒内に所定圧力まで充填するステップと、前記供給口の開閉弁と前記排出口の開閉弁を閉じた状態で前記照明光を照射して前記光学素子の表面に付着した汚染物質を浮遊させるステップと、前記供給口の開閉弁と前記排出口の開閉弁を開いて前記ガスを前記鏡筒の内外に流通させるステップと、前記供給口の開閉弁と前記排出口の開閉弁を閉じるステップとからなる洗浄方法により洗浄することにより、上記目的を達成する。

前記排出口の開閉弁を閉じるのに先立ち、前記供給口の開閉弁および前記排出口の開閉弁を開いた状態で前記不活性ガスを前記複数の室のそれぞれに流すようにしてもよい。また、前記光学装置を、前記複数の室を所定数ずつ少なくとも2つのグレープに区分し、区分されたグループごとにそれぞれ前記ガスの供給口と排出口を設け、前記供給口と排出口にはそれぞれ開閉弁を設けて構成してもよい。

本発明の投影露光装置は、照明光をマスクに照射し、該マスク上のパターンを投影光学系を介して基板上に転写する投影露光装置において、鏡筒内に配設された複数の光学素子の間に形成される複数の室のそれぞれに前記照明光の吸収が少ないガスの供給口と排出口を設け、前記供給口と排出口にはそれぞれ開閉弁を設けて構成した光学装置を備え、該光学装置を、前記供給口の開閉弁を開く一方、前記排出口の開閉弁を閉じた状態で前記ガスを前記鏡筒内に所定圧力まで充填するステップと、前記供給口の開閉弁と前記排出口の開閉弁を閉じた状態で前記照明光を照射して前記光学素子の表面に付着した汚染物質を浮遊させるステップと、前記供給口の開閉弁と前記排出口の開閉弁を開いて前記ガスを前記鏡筒の内外に流通させるステップと、前記供給口の開閉弁と前記排出口の開閉弁を閉じるステップとからなる洗浄方法によって洗浄することにより、上記目的を達成する。

前記光学装置は、前記投影光学系及び／又は前記照明光を前記マスクに照射する照明光学系として用いられる。

また、本発明の別の露光装置によれば、マスクのパターンを基板上に転写する露光装置において、照明ビームを射出する光源と前記基板との間に配置される光学系と、光学素子を保持する鏡筒の少なくとも一端に保護フィルタが配置され、前記鏡筒内に前記照明ビームの吸収が少ない気体が充填された光学ユニットとを備え、前記光学ユニットを前記光学系内に配置することにより、上記目的を達成する。

前記光学系は、前記照射ビームを前記マスクに照射する照明光学系を含み、前記光学ユニットは前記照明光学系内に配置される。また、前記光学系への前記光学ユニットの取付時に、前記保護フィルタは前記鏡筒から取り外されるか、又は別の保護フィルタと交換される。また、前記光学系内に前記照明ビームの吸収が少ない気体を供給する気体供給装置を更に備え、前記光学系内に前記気体を充填した状態で前記照明ビームを通した後に前記気体供給装置を動作させることが好ましい。さらに、前記光学系内の気体を排出する排気装置を更に備え、前記光学系内に前記気体を充填又は供給する前に前記排気装置を動作させることが好ましい。前記照明ビームの波長は１００乃至２００ｎｍの範囲内であり、また前記照明ビームはＡｒＦレーザ、又はF_2レーザで、前記気体は窒素、又はヘリウムで

ある。

また、本発明の別の露光装置によれば、マスクのパターンを基板上に転写する露光装置において、照明ビームを射出する光源と前記基板との間に配置される光学系と、前記光学系の少なくとも一部に、前記照明ビームの吸収が少ない気体を供給する気体供給装置と、前記気体の供給に先立って前記少なくとも一部から気体を排出する排気装置とを備えることにより、上記目的を達成する。

前記光学系は、前記照明ビームを前記マスクに照射する照明光学系と、前記光源と前記照明光学系との間に配置される送光系と、前記マスクから出射する照明ビームを前記基板上に投影する投影光学系とを含む。また、前記照明ビームの照射による前記光学系の光洗浄後に、前記排気装置と前記気体供給装置とを順次動作させることが好ましい。前記照明ビームの波長は１００乃至２００ｎｍの範囲内であり、また前記照明ビームはＡｒＦレーザ、又はF_2レーザで、前記気体は窒素、又はヘリウムである。

本発明の露光装置の製造方法は、マスクを介して照明ビームで基板を露光する装置の製造方法において、光学素子を保持する鏡筒の少なくとも一端に保護フィルタを配置して、前記鏡筒内に前記照明ビームの吸収が少ない気体を充填し、前記照明ビームを射出する光源と前記基板との間に前記鏡筒を配置することにより、上記目的を達成する。

前記鏡筒の配置後、前記保護フィルタを取り外すか、又は前記保護フィルタを別の保護フィルタに交換する。

本発明の別の製造方法によれば、マスクを介して照明ビームで基板を露光する装置の製造方法にして、前記照明ビームを通す光学系の少なくとも一部に洗浄光を照射し、前記光学系内の気体を、前記照明ビームの吸収が少ない気体に置換することにより、上記目的を達成する。

図面の簡単な説明

図１は本発明による露光装置の実施の形態を示す図。

図２はガスセルＧＳの詳細図。

図３は照明レンズユニット２を説明する図であり、（ａ）は断面図、（ｂ）は（ａ）のクイックカプラＱ１部分の拡大図。

図４は照明レンズユニット２の照明光学系ＩＬへの組み付け手順を説明する図。

図５は投影レンズユニット４の断面図。

図６は図５に示す投影レンズユニットの第１の変形例を示す図。

図７は図５に示す投影レンズユニットの第２の変形例を示す図。

図８は図７に示す管路Ｌ１２の断面図。

発明の実施の形態

以下、図１～図８を参照して本発明の実施の形態を説明する。

図１は、本発明の実施の形態に係る露光装置の構成を模式的に説明する図であり、図示の装置はその装置本体が収納されるチャンバーとは別設され、ＡｒＦエキシマレーザ光を射出する光源１を備えている。光源１を出射した光ビームの一部は送光系、すなわちビームスプリッタ（パーシャルミラー）Ｍｐを透過してミラーM_{11}方向に進み、残部は反射されてミラーM方向に進む。ビームスプリッタＭｐを透過した光は送光系内のミラーM_{11}、M_{12}および照明光学系ＩＬ内のミラーM_{13}で反射され、照明光学系ＩＬに設けられた照明レンズユニット２を介してレチクルＲを均一に照明する。図１では、送光系と照明光学系ＩＬとが一体に構成されているものとして図示している。また、図１では照明レンズユニット２を一つしか図示していないが、通常、照明光学系ＩＬは照明レンズユニット２を複数備えている（例えば、フライアイレンズユニット，リレーレンズユニット，コンデンサーレンズユニット等）。送光系および照明光学系ＩＬは容器によって包囲されており、この容器内にはバルブＶ１を介してＡｒＦ光を吸収しないか、又は吸収が少ない気体、たとえば窒素ガス（またはヘリウムガス）が供給される。図示していないが、レチクルＲはステージ上に載置され、照明光学系ＩＬの視野絞りのスリット等を介して射出される照明光に対して相対移動される。

レチクルＲを透過した光は、投影光学系ＰＬを構成する種々の光学部材（レンズエレメントおよび／またはミラー）を介してウェハステージＷＳに載置されたウェハＷの表面上に到達し、レチクルＲ上のパターンを結像する。ウエハステージＷＳは、照明光で照射されるレチクルＲから発生して投影光学系ＰＬを通過する光に対してウエハＷを相対移動する。露光の際には、レチクルＲとウェハＷが投影光学系の倍率に対応した速度比で互に逆方向に走査される。投影光学系ＰＬ

には少なくとも１つ以上の投影レンズユニット４が設けられ、照明光学系ＩＬと同様に容器により包囲されている。この容器にはバルブＶ２を介して窒素ガスが供給されるようになっている。なお、照明レンズユニット２および投影レンズユニット４の詳細については後述する。

照明光学系ＩＬを包囲している容器に設けられたバルブＶ３は窒素ガス排出用のバルブであり、バルブＶ３から排出された窒素ガスはロータリーポンプＲＰを介して排気ダクトに送られる。また、投影光学系ＰＬを包囲している容器にも窒素ガス排出用バルブＶ４が設けられ、排出された窒素ガスはロータリーポンプＲＰを介して排気ダクトに送られる。光源１から出射されビームスプリッタＭｐで反射された光は、適宜配設された複数のミラーＭで反射され、レンズＬを介してガスセルＧＳ内に入射する。ガスセルＧＳには減圧弁ＲＧを介して窒素ガスが供給されるようになっており、図２の詳細図に示すようにガスセルＧＳにはオリフィスＯが形成され、このオリフィスＯを封止するようにレンズＬが配置されている。レンズＬを介してガスセルＧＳ内に入射した光は、ガス供給口１０とガス排出口１１を結ぶ軸線上で合焦するように構成されており、ガスセルＧＳ内において窒素ガスは紫外光による二光子吸収作用によりイオン化される。

ガスセルＧＳから排出されたイオン化窒素ガスは三経路に分れた後に、バルブＶ５を介してレチクルＲおよびレチクルステージを包囲する容器内に、バルブＶ６を介して投影光学系ＰＬの下端部に、バルブＶ７を介してウェハステージＷＳにそれぞれ供給される。レチクルＲおよびレチクルステージを包囲する容器は窒素ガス排出用バルブＶ８を備えており、排出された窒素ガスは、酸素センサＳおよびロータリポンプＲＰを介して排気ダクトに連通している。

－照明レンズユニットの詳細説明－

図３（ａ）は照明光学系ＩＬに設けられる照明レンズユニット２の断面図である。鏡筒２６内にはレンズ２１～２５およびレンズ間を所定の間隔に保つレンズ分離環２７～３０が収められ、押さえ環３１によって固定される。鏡筒２６はケーシング３２に収められ、ケーシング３２の図示上下の開口部には蓋３３，３４がＯリングシールＳ１，Ｓ２を介して取り付けられる。なお、蓋３３は枠３５にガラス部材３６を取り付けたものであり、また蓋３４は枠３７にガラス部材３８

を取り付けたものである。ケーシング３２には窒素ガスを供給するための管路Ｌ３ａおよび窒素ガス排出用管路Ｌ３ｂが設けられ、管路Ｌ３ａ，Ｌ３ｂにはバルブＶ１０，Ｖ１１が設けられる。供給用の管路Ｌ３ａは３つの管路Ｌ３a_1，Ｌ３a_2，Ｌ３a_3に分岐され、管路Ｌ３a_1はクイックカプラＱ１を介してガス供給口Ｇ１に接続され、管路Ｌ３a_2クイックカプラＱ２を介してガス供給口Ｇ２に接続され、管路Ｌ３ａ3はクイックカプラＱ３を介してガス供給口Ｇ３に接続され、管路Ｌ３ｂはクイックカプラＱ４を介してガス排出口Ｇ４に接続される。

図３（ｂ）は管路Ｌ３a_1のクイックカプラＱ１部分の拡大図であり、クイックカプラＱ１の下流側には窒素ガスを通してケーシング３２内に汚染物質が進入しないようにケミカルフィルタＦが設けられる。同様に、他の管路Ｌ３a_2，Ｌ３a_3についてもケミカルフィルタＦが設けられる。なお、ケミカルフィルタＦについては後述する。

管路Ｌ３ａから窒素ガスを供給すると、管路Ｌ３a_1を介してガス供給口Ｇ１に供給された窒素ガスは蓋３３およびレンズ２１間のレンズ室を矢印Ａ１のように流れた後、ガス排出口Ｇ４から管路Ｌ３ｂに排出される。管路Ｌ３a2 を介してガス供給口Ｇ２に供給された窒素ガスは、矢印Ａ２，Ａ３およびＡ４で示すようにレンズ２１とレンズ２２との間，レンズ２２とレンズ２３との間，レンズ２３とレンズ２４との間およびレンズ２４とレンズ２５との間の各レンズ室を通過した後、ガス排出口Ｇ４から管路３ｂに排出される。さらに、管路Ｌ３a3 を介してガス供給口Ｇ３に供給された窒素ガスは、蓋３４よびレンズ２５間のレンズ室を矢印Ａ５のように流れた後にガス排出口Ｇ４から管路Ｌ３ｂに排出される。

ところで、鏡筒２６の組立は通常大気中で行われるため、レンズ２１～２５の表面に汚染物質が付着するのは避けられない。しかしながら、上述した照明レンズユニット２では、後述するようにレンズ２１～２５に付着した汚染物質の除去を容易に行うことができ、さらに、照明光学系ＩＬに組み付けを行う際に、汚染物質がレンズ表面に付着するのを避けることができる。

まず、バルブＶ１０を閉じた状態でバルブＶ１１を開いてケーシング３２内を真空排気する。その後、バルブＶ１１を閉じ、バルブＶ１０を開いてケーシング３２内に窒素ガスを充填し、その状態でＡｒＦ光を蓋３３のガラス部材を通して

レンズ２１～２５に照射する。ＡｒＦ光を照射すると、レンズ２１～２５の表面およびガラス部材３６，３８の内側の面に付着した汚染物質は剥離され窒素ガス中に浮遊する。このような照射を行いながらバルブＶ１１を開いてケーシング３２内の窒素ガスを排出させると、窒素ガスとともにガス中に浮遊している汚染物質がケーシング３２外へ排出される。その後、ケーシング３２内に窒素ガスを供給した状態でバルブＶ１１を閉じてケーシング３２内を所定圧力にしてバルブＶ１０を閉じ、その状態で照明レンズユニット２を保管する。なお、上述したように窒素ガスをケーシング３２内に充填した状態ではなく、窒素ガスを流し続けながらＡｒＦ光または低圧水銀ランプから射出される波長１８５ｎｍと２５４ｎｍの光ビームを照射して汚染物質を除去するようにしても良い。なお、後者の低圧水銀ランプを用いる場合には、その低圧水銀ランプを光源１と並置し、そのランプから射出される光ビームをレンズおよび／またはミラーで送光系に導くように構成し、それ以降の光学系を兼用させてもよい。

このようにして、鏡筒２６組立時にレンズ２１～２５の表面に付着した汚染物質を容易に除去することができるとともに、照明レンズユニット２を照明光学系ＩＬに組み付けるまでのレンズ２１～２５の汚染を避けることができる。

次に、照明光学系ＩＬへの照明レンズユニット２の組み付け手順を図４を用いて説明する。まず、照明光学系ＩＬを大気開放し、照明レンズユニット２の管路Ｌ３ａを照明光学系ＩＬに設けられたバルブＶ１の窒素ガス供給用配管に接続する。次いで、バルブＶ１およびバルブＶ１０を開きバルブＶ１１を閉じて窒素ガスをケーシング３２内へ供給する。そして、窒素ガスを供給したまま蓋３３，３４（図３参照）を取外した後にバルブＶ１１を開き照明光学系ＩＬを閉じる。このとき、各レンズ間のレンズ室においては窒素ガスが矢印Ａ１～Ａ４のように流れ、かつ、管路Ｌ３ａ，Ｌ３ｂにより供給される窒素ガスは矢印Ａ６のような流れとなるため、レンズ２１，２５の開口側表面は窒素ガスによって大気から遮断されることとなる。よって、照明レンズユニット２を照明光学系ＩＬに組み付ける際にも、レンズ２１～２５の汚染を防ぐことが可能となる。

なお、後述するように、照明レンズユニット２を組み付けた後にバルブＶ３を介して照明光学系ＩＬ内が真空排気され、さらに、バルブＶ１から窒素ガスが供

給される。そのとき、クイックカプラＱ５を介して管路Ｌ３ａに供給された窒素ガスは照明レンズユニット２を循環した後に照明光学系ＩＬ内に流出し、バルブＶ３を介して外部に排出される。また、上述した説明では、照明レンズユニット２を露光装置に組み付ける際に蓋３３，３４を取外したが、装置構成によっては蓋３３，３４を取り付けたまま組み付けるようにすることもできる。そのような場合、蓋３３，３４のガラス部材３６，３８の大気側表面は水分の付着等によって汚染されているので、照明レンズユニット２を装置に組み付ける際に、蓋３３，３４を汚染されていない新しい蓋と取り替えるようにすれば、照明レンズユニット２からの汚染物質の除去を確実なものとすることができる。なお、上述したように窒素ガスを供給し照明光を照射することによって汚染物質を除去する方法は、照明レンズユニット２に限らず投影レンズユニット４に対しても適用することができる。

－投影レンズユニット４の詳細説明－

図５は投影光学系ＰＬに設けられる投影レンズユニット４の概略を示す断面図である。投影レンズユニット４の鏡筒４１内には３枚のレンズ４２～４４が所定の間隔で設けられており、押さえ環４５によって固定される。４６はレンズ４３とレンズ４４との間を所定の間隔に保つためのレンズ分離環である。実際には、投影レンズユニット４は多数のレンズを備えているが、図５では説明を簡略化するためにその内の３枚だけ示した。レンズ４２，４３間およびレンズ４３，４４間にはレンズ室Ｒ１，Ｒ２が形成される。レンズ室Ｒ１にはクイックカプラＱ６が取り付けられているガス供給口Ｇ６と、クイックカプラＱ７が取り付けられているガス排出口Ｇ７とが設けられ、一方、レンズ室Ｒ２にはクイックカプラＱ８が取り付けられているガス供給口Ｇ８と、クイックカプラＱ９が取り付けられているガス排出口Ｇ９とが設けられる。また、ガス供給口Ｇ６とクイックカプラＱ６との間、および、ガス供給口Ｇ８とクイックカプラＱ８との間にはそれぞれケミカルフィルタＦ１，Ｆ２が設置されている。ケミカルフィルタＦ１，Ｆ２は供給される窒素ガス中の有機物やアルコール等の不純物を除去するために設けたものである。

ケミカルフィルタについて詳細に説明すると、イオン除去用フィルタとしては

イオン交換樹脂，イオン交換繊維等があるが、表面積および反応速度が大きく成形加工が容易なことから気体処理用としてはイオン交換繊維が適当である。イオン交換繊維は、例えばポリプロピレン繊維から放射線グラフト重合によって作られる。イオン交換繊維には酸性カチオン交換繊維と塩基性アニオン交換繊維との２種類があり、NH_4^+やアミンなどのプラスイオンや塩基性ガスでは酸性カチオン交換繊維が用いられ、一方、SO_4^{2-}やNOx 等のマイナスイオンや酸性ガスでは塩基性アニオン交換繊維が用いられる。

図５ではクイックカプラＱ６～Ｑ９のそれぞれの管路Ｌ１６～Ｌ１９にバルブＶ１６～Ｖ１９を設けられており、各ガス供給口Ｇ６，Ｇ８に供給するガスの流れをレンズ室Ｒ１，Ｒ２毎に制御することができる。この投影レンズユニット４の場合も、前述した照明レンズユニット２の場合と同様に鏡筒組立の際にレンズ４２～４４の表面に汚染物質が付着するのは避けられない。しかし、ガス供給口Ｇ６，Ｇ８から窒素ガスを流してＡｒＦ光を照射することにより、照明レンズユニット２の場合と同様の手順でレンズ表面に付着した汚染物質を取除くことができる。汚染物質除去の手順については照明レンズユニット２の場合と同様なので、説明を省略する。

なお、図５に示す例では、各管路Ｌ１６～Ｌ１９の各々にバルブを設けてレンズ室毎にガスの流れを制御できるような構造としたが、レンズ室Ｒ１，Ｒ２を流れるガス流量が極端に低下しないような範囲において、図６のように複数の管路Ｌ１６とＬ１８をまとめた管路Ｌ１２に１つのバルブＶ１２を設け、管路Ｌ１７とＬ１９をまとめて１つのバルブＶ１３を設けてガスの流れを制御するようにしてもよい。図６に示した投影レンズユニット４では、レンズを３枚しか図示しなかったのでまとめて排気するレンズ室のセットが１つしかないが、実際には多数のレンズが設けられるのでレンズ室の数も多くなる。そのような場合、複数まとめて排気するレンズ室のセットの数は２以上となる。また、図５，６のように全てのレンズ室に対してガス供給口，ガス排出口を設けないで、設計的に最も効果の期待できるレンズ室のみに配管を設けるようにしても良い。

図７は図６に示した投影レンズユニットの変形例を示す図であり、図６と同一部分には同一の符号を付し、以下では異なる部分を中心に説明する。投影レンズ

ユニット４'では、図７およびガス供給用管路Ｌ１２の断面を示す図８のようにレンズ室Ｒ１，Ｒ２の内壁およびガス供給用管路Ｌ１２の内壁に吸着材Ａｄが塗布され、窒素ガス供給源Ｔから供給される窒素ガス中の水分等を除去する。吸着材としては、活性炭，シリカゲル，ゼオライト等が用いられる。なお、ＬＦはラインフィルタ、Ｖ１４はバルブである。

以上のように構成された照明レンズユニット２および投影レンズユニット４を露光装置に組み付けた後の動作について説明する。照明光学系ＩＬ、投影光学系ＰＬおよびレチクルＲをそれぞれ包囲する容器が、対応するバルブＶ３、Ｖ４およびＶ８を介してロータリポンプＲＰの作用により順次真空排気される。このとき、照明レンズユニット２および投影レンズユニット４の内部も同時に真空排気される。各容器内の真空の度合いは、対応する酸素センサＳにより検出した酸素濃度に基づいて知ることができる。所望の真空状態を実現した後、照明光学系ＩＬおよび投影光学系ＰＬをそれぞれ包囲する容器には、それぞれバルブＶ１およびＶ２を介して窒素ガスを大気圧以上になるまで供給する。また、レチクルＲを包囲する容器には、バルブＶ５を介して適当にイオン化された窒素ガスを大気圧以上になるまで供給する。イオン化された窒素ガスの作用により、レチクルＲに発生した静電気を除去することができ、静電気に起因するようなレチクルＲの損傷を未然に防止することができる。

一方、投影光学系ＰＬとウェハＷとの間には、バルブＶ６を介してイオン化された窒素ガスがウェハＷに向かってウェハＷにほぼ垂直に供給される。さらに、バルブＶ７を介してウェハＷの表面を大気から遮断するようにイオン化された窒素ガスが供給される。そのため、イオン化された窒素ガスの作用によりウェハＷに発生した静電気を除去することができ、静電気に起因するようなウェハＷの損傷、汚れを未然に防止することができる。

ウェハの露光投影中およびウェハの交換時にも、投影光学系ＰＬとウェハＷとの間にはイオン化された窒素ガスがほぼ連続的に供給される。このため、ウェハの交換の際にも、窒素ガス雰囲気は実質的に破られることがない。また、レチクルＲを包囲する容器に関しては、レチクルＲを交換する必要がある場合に限り、交換の後に新たに真空引きを行ってイオン化された窒素ガスを供給する必要があ

る。一方、照明光学系ＩＬおよび投影光学系ＰＬを包囲する容器に関しては、窒素ガスを充填した状態でバルブＶ１～Ｖ４を閉じても良いし、窒素ガスを連続的に供給するようにしても良い。特に、窒素ガスを連続的に供給する場合には以下のような利点を有する。

すなわち、上述したように照明レンズユニット２や投影レンズユニット４の組立後に汚染物質の除去が行われた場合でも、ケーシング３２やレンズ室Ｒ１，Ｒ２の内壁面に付着した水分等が放出されることにより露光装置に組み付け後にレンズ表面が水分等により汚染されるおそれがある。しかし、上述したように組み付け後に窒素ガスを連続的に供給する場合には、露光動作によってＡｒＦ光が各レンズに照射され、それによってレンズ表面から剥離した汚染物質は窒素ガスとともに容器外に排出されることになる。そのため、内壁面からの水分放出等があっても、レンズ表面が再汚染されることがない。なお、上述した実施の形態では、複数のレンズから成る照明レンズユニット２，投影レンズユニット４を例に説明したが、反射鏡から成る光学系についても同様に本発明を適用することができる。

また、上述したように鏡筒内外に不活性ガスを連続的に流通させた場合には、露光装置内の照明光学系，投影光学系または送光系の鏡筒（保持部材）にレンズ等の光学素子を固定する接着剤または充填材に紫外波長域の放射ビームが照射され、接着剤や充填材から発生するアウトガス（有機物など）やアウトガスによる反応物などが発生した場合でも、それらが光学部材へ付着したり光路内へ進入（浮遊）したりすることを防止でき、光ビームの照射に伴う光学部材の光学特性（透過率、反射率など）や、投影光学系における焦点位置，投影倍率，ザイデルの５収差，テレセントリシティ等の光学特性の変動を防止することができる。その結果、マスクまたは基板上での照明光の強度変化を防止することができて常に適正な露光量でマスクのパターンを基板上に転写することが可能となるとともに、常に良好な結像条件でパターン像を基板上に投影することができる。

さらに、上述した汚染物質除去方法を利用することによって、半導体素子，薄膜磁気ヘッド，撮像素子（ＣＣＤ）等のマイクロデバイスを製造するリソグラフィー工程で使用される露光装置における光学部材の所謂光洗浄を容易に行うことが可能となる。すなわち、露光動作に先立って、照明光学系，投影光学系あるい

は送光系等を装置に組込んだままで例えば波長１８５ｎｍと２５４ｎｍの光ビーム，または露光用照明光を光学部材に照射して、その表面に付着した物質（アウトガスまたはその反応物、あるいは鏡筒内壁から発生する水やハイドロカーボンなどの不純物）を除去することができる。

なお、本発明による光学装置や洗浄方法が適用される露光装置内の光学系には、例えばオプティカルインテグレータ（フライアイレンズ）やコンデンサーレンズなどの複数の光学素子を有し露光光でマスクを照明する照明光学系や、光軸に沿って配列される複数の光学要素（屈折素子および／または反射素子）からなり、マスクに形成されたパターンの像を基板（半導体ウエハ等）上に投影する投影光学系（例えば、カタディオプティック光学系も含む）等がある。さらには、以下のような光学系がある。すなわち、（１）照明光学系の光軸と照明光との位置関係を調整するための少なくとも１つの光学要素（可動ミラーや平行平面板など）を有し、クリーンルームの床下に露光装置本体とは分離して配置される光源から射出された照明光を本体内の照明光学系に導く送光系、（２）マスクや基板上のアライメントマークに紫外波長域の照明光を照射し、その位置を検出するアライメント光学系、（３）投影光学系の光学特性（上述した投影倍率など）を検出する計測装置の光学系であって、マスクや基板が載置されたステージ上の基準マークまたは計測用マークに露光光または露光光とほぼ同一波長の照明光で照射したときに、マークから発生して投影光学系を通る光を受光する計測用光学系がある。

そして、本発明を上述したアライメント光学系に適用した場合、光学部材の透過率または反射率の変動によるアライメントマークに照射される照明光（アライメント光）の強度変化を防止できる。また、アウトガスやその反応物等によるアライメントマーク上での照明光の照度均一性の低下（照度むらの発生）や、アライメントマーク上の１点に集る照明光束が通過するアライメント光学系の瞳面上の領域内における光強度の均一性の低下による、照明光のテレセントリシティの崩れ（劣化）等を防止することができる。その結果、アライメントマークの位置検出精度を低下させることなく、マスクと基板とを高精度にアライメントすることができる。

さらに、計測用光学系に適用した場合、アライメント光学系と同様に、光学部

材の透過率または反射率の変動によるマーク上での照明光強度変化、および照度不均一性やテレセントリシティの低下を防止できる。その結果、投影光学系の光学特性を高精度に検出することが可能となる。

また、波長１５７ｎｍのF_2レーザを露光用光源とする露光装置に対しても本発明を適用できる。すなわち、本発明は波長１００ｎｍ乃至２００ｎｍの真空紫外光（ＶＵＶ光）、特に波長１５０ｎｍ乃至２００ｎｍのＶＵＶ光に対しても有効である。これは１５０ｎｍより短い波長域の光では硝材、コーティング材などの制約が大きくなるためである。

以上説明した発明の実施の形態と特許請求の範囲の要素との対応において、レチクルＲはマスクを、照明レンズユニット２および投影レンズユニット４，４’は光学レンズ装置を、蓋３３，３４は保護フィルタを、管路Ｌ１２は供給通路を、バルブＶ１２は可動部材をそれぞれ構成する。尚、本明細書では“不活性ガス”として窒素を含むものとして説明してある。

以上説明したように、本発明によれば次のような効果が得られる。

すなわち、複数の光学素子の両端との間に所定の空間を形成する保護フィルタを設け、複数の光学素子の間の室はもとより両端の光学素子と保護フィルタとの間の空間にも不活性ガスが充填されるようにしたので、光学装置単体で組み立てた後に上記室と空間を不活性ガスでパージして洗浄することができ、これにより両端の光学素子の汚染がない状態で光学装置を投影露光装置に組み付けることがでできる。

また、保護フィルタと両端の光学素子との間の空間を不活性ガスでパージしながら組み立てるようにしたので、組み立て時の光学素子あるいは保護フィルタの汚染を防止できる。

また、保護フィルタと両端の光学素子との間の空間を不活性ガスでパージしながら保護フィルタを取外し、その後、予め洗浄されている保護フィルタを取り付けるようにしたので、組み立て時の光学素子あるいは保護フィルタの汚染を防止できる。

また、不活性ガスの供給通路や鏡筒の内面に吸着材を設けたので、供給される不活性ガス中に汚染物質が含まれていても吸着材に吸着され、レンズ表面や反射

鏡表面が汚染されるおそれがない。

また、電磁弁のような可動部材の下流にフィルタを設けたので、可動部材で発生した汚染物質によるレンズ表面や反射鏡表面の汚染を防止することができる。

また、複数の光学素子の間の複数の室のそれぞれを個別に不活性ガスでパージ可能としたので、汚染物質が確実に除去できる。

また、複数の光学素子の間の複数の室を所定数ずつ少なくとも２つのグループに区分し、その区分したグループごとに不活性ガスでパージ可能としたので、ガス流通制御のための弁を最小限に抑えることができ、コストダウンに寄与する。

また、光学装置に不活性ガスを充填した後に照明光を照射して光学素子に付着している汚染物質を浮遊させ、その後で不活性ガスを光学装置から排出するようにしたので、光学装置単体の状態で光学素子表面に付着した汚染物質を除去することができる。

また、予め洗浄された光学装置を照明光学系や投影光学系として投影露光装置に組み付けるようにしたので、組み立て直後でもレンズの透過率低下や反射鏡の反射率低下を抑えることができる。

また、投影光学系や送光系などの汚染を防止することができ、投影光学系や送光系の光学特性の変動を抑え、高精度な投影露光を行うことができる。

請 求 の 範 囲

1．内部に複数の光学素子が配置された鏡筒の軸線方向両端に、前記複数の光学素子のうち前記鏡筒の軸線方向両端側に配置された光学素子との間に所定間隔をあけて保護フィルタを配置し、

前記複数の光学素子間の室および前記両端側の光学素子と前記保護フィルタとの間の空間に、予め不活性ガスをそれぞれ充填してなることを特徴とする光学装置。

2．請求項1に記載の光学装置にして、

前記光学装置は、照明光をマスクに照射し、該マスクを介して該照明光で基板を露光する装置に装備され、

前記不活性ガスは、前記照明光の吸収が少ない不活性ガスであることを特徴とする光学装置。

3．請求項2に記載の光学装置にして、

前記照明光の波長は３５０ｎｍ以下であることを特徴とする光学装置。

4．請求項2又は3に記載の光学装置にして、

前記光学装置が、前記露光装置に装備された照明光学系の光路筐体中に設置される際、前記空間を前記ガスでパージしながら前記保護フィルタを取り外すようにし、その後前記光路筐体内に前記ガスを充填するようにしたことを特徴とする光学装置。

5．請求項2又は3に記載の光学装置にして、

前記光学装置が、前記露光装置の照明光学系の光路筐体中に設置される際、前記空間を前記ガスでパージしながら前記保護フィルタを取り外し、予め洗浄された新たな保護フィルタを前記鏡筒の軸線方向両端に取り付けるようにし、その後前記光路筐体内に前記ガスを充填するようにしたことを特徴とする光学装置。

6．請求項2に記載の光学装置にして、

前記露光装置は、前記マスクを前記照明光に対して相対移動させるとともに、前記基板を前記露光装置の投影光学系に対して相対移動させる、ステージシステムをさらに装備してなることを特徴とする光学装置。

７．請求項２に記載の光学装置にして、

前記照明光の照明光源は前記露光装置と別個に設けられ、

前記照明光源から射出される照明光を前記投影露光装置内の照明光学系に導くとともに、前記照明光学系の光軸と前記照明光との位置関係を調整する少なくとも１つの光学要素を有する送光系を設け、

前記送光系を前記照明光吸収が少ないガスが充填される鏡筒内に配置してなることを特徴とする光学装置。

８．複数の光学素子が配設された鏡筒内に不活性ガスを供給する供給通路と、

前記供給通路が接続される供給口と、

前記鏡筒内の不活性ガスを排出する排出口とを備え、

前記供給通路の内壁に汚染物質を除去する除去部材を設けたことを特徴とする光学装置。

９．請求項８に記載の光学装置にして、

前記光学装置は、照明光をマスクに照射し、該マスクを介して該照明光で基板を露光する装置に装備され、

前記不活性ガスは、前記照明光の吸収が少ないガスであることを特徴とする照明用光学装置。

１０．請求項９に記載の光学装置にして、

前記照明光の波長は３５０ｎｍ以下であることを特徴とする光学装置。

１１．請求項９又は１０に記載の光学装置にして、

前記露光装置は、前記マスクに前記照明光を照射する照明光学系と、前記マスクから出射する照明光を前記基板に投影する投影光学系とを更に備え、

前記光学装置が前記照明光学系と前記投影光学系との少なくとも一部に装備されることを特徴とする光学装置。

１２．請求項１１に記載の光学装置にして、

前記露光装置は、前記照明光に対して前記マスクを相対移動するとともに、前記マスクの移動に同期して、前記投影光学系から射出される照明光に対して前記基板を相対移動するステージシステムをさらに装備してなることを特徴とする光学装置。

１３．請求項１１に記載の光学装置にして、

前記露光装置は、前記照明光を射出する光源と前記照明光学系との間に配置される送光系を更に備え、前記送光系を前記照明光の吸収が少ないガスが充填される筐体内に配置してなることを特徴とする光学装置。

１４．請求項１３に記載の光学装置にして、

前記光源は前記露光装置と別個に設けられ、前記送光系は、前記照明光学系の光軸と前記光源から射出される照明光との位置関係を調整する光学素子を有することを特徴とする光学装置。

１５．請求項８乃至１０に記載の光学装置にして、

前記供給通路に設置される可動部材をさらに備え、

前記除去部材は、吸着材又はフイルタであることを特徴とする光学装置。

１６．マスク上のパターンを基板上に転写する露光装置に装備される光学装置にして、前記光学装置は、

複数の光学素子が配設された鏡筒の内面に汚染物質の除去部材を設けたことを特徴とする光学装置。

１７．請求項１６に記載の光学装置にして、

前記露光装置は、前記パターンの像を前記基板上に投影する投影光学系を有することを特徴とする光学装置。

１８．照明光をマスクに照射して、該マスク上のパターンを基板上に転写する露光装置に用いられる光学装置にして、前記光学装置は、

鏡筒内に配設された複数の光学素子の間に形成される複数の室のそれぞれに前記照明光の吸収が少ないガスの供給口と排出口を設け、前記供給口と排出口にはそれぞれ開閉弁を設けたことを特徴とする光学装置。

１９．請求項１８に記載の光学装置にして、

前記露光装置は、前記パターンの像を前記基板上に形成するために、前記マスクと前記基板との間に配置される投影光学系を有することを特徴とする光学装置。

２０．請求項１８又は１９に記載の光学装置にして、

前記鏡筒内に配設された複数の光学素子の間に形成される複数の室を所定数ずつ少なくとも２つのグループに区分し、区分されたグループごとにそれぞれ前記

ガスの供給口と排出口を設け、前記供給口と排出口にはそれぞれ開閉弁を設けたことを特徴とする光学装置。

２１．照明光をマスクに照射して、該マスク上のパターンを基板上に転写する露光装置に用いられる光学装置の洗浄方法にして、

前記光学装置は、鏡筒内に配設された複数の光学素子の間に形成される複数の室のそれぞれに前記照明光の吸収が少ないガスの供給口と排出口を設け、前記各供給口と排出口にはそれぞれ開閉弁を設けて構成され、

前記洗浄方法は、前記供給口の開閉弁を開く一方、前記排出口の開閉弁を閉じた状態で前記ガスを前記鏡筒内に所定圧力まで充填するステップと、

前記供給口の開閉弁と前記排出口の開閉弁を閉じた状態で前記照明光を照射して前記光学素子の表面に付着した汚染物質を浮遊させるステップと、

前記供給口の開閉弁と前記排出口の開閉弁を開いて前記ガスを前記鏡筒の内外に流通させるステップと、

前記供給口の開閉弁と前記排出口の開閉弁を閉じるステップとからなることを特徴とする光学装置の洗浄方法。

２２．請求項２１に記載の洗浄方法にして、

前記排出口の開閉弁を閉じるのに先立ち、前記供給口の開閉弁および前記排出口の開閉弁を開いた状態で前記ガスを前記複数の室のそれぞれに流すことを特徴とする光学装置の洗浄方法。

２３．請求項２１に記載の洗浄方法にして、

前記光学装置は、前記複数の室を所定数ずつ少なくとも２つのグループに区分し、区分されたグループごとにそれぞれ前記ガスの供給口と排出口を設け、前記供給口と排出口にはそれぞれ開閉弁を設けて構成されてなることを特徴とする光学装置の洗浄方法。

２４．照明光をマスクに照射し、該マスク上のパターンを投影光学系を介して基板上に転写する投影露光装置において、

鏡筒内に配設された複数の光学素子の間に形成される複数の室のそれぞれに前記照明光の吸収が少ないガスの供給口と排出口を設け、前記供給口と排出口にはそれぞれ開閉弁を設けて構成した光学装置を備え、

前記光学装置は、前記供給口の開閉弁を開く一方、前記排出口の開閉弁を閉じた状態で前記ガスを前記鏡筒内に所定圧力まで充填するステップと、前記供給口の開閉弁と前記排出口の開閉弁を閉じた状態で前記照明光を照射して前記光学素子の表面に付着した汚染物質を浮遊させるステップと、前記供給口の開閉弁と前記排出口の開閉弁を開いて前記ガスを前記鏡筒の内外に流通させるステップと、前記供給口の開閉弁と前記排出口の開閉弁を閉じるステップとからなる洗浄方法によって洗浄されていることを特徴とする投影露光装置。

２５．請求項２４に記載の投影露光装置にして、

前記光学装置は、前記投影光学系及び／又は前記照明光を前記マスクに照射する照明光学系として用いられることを特徴とする投影光学装置。

２６．請求項２４に記載の投影露光装置にして、

前記マスクを前記照明光に対して相対移動させるとともに、前記マスクの移動に同期して、前記基板を前記投影光学系から射出される照明光に対して相対移動させる、ステージシステムをさらに装備してなることを特徴とする投影露光装置。

２７．請求項２４に記載の投影露光装置にして、

前記照明光を射出する光源と前記照明光を前記マスクに照射する照明光学系との間に配置される送光系を更に備え、前記送光系を前記照明光の吸収が少ない筐体内に配置してなることを特徴とする投影露光装置。

２８．請求項２７に記載の投影露光装置にして、

前記光源は前記投影光学系と別個に設けられ、前記送光系は、前記照明光学系の光軸と前記光源から射出される照明光との位置関係を調整する光学要素を有することを特徴とする投影露光装置。

２９．請求項２４に記載の投影露光装置にして、

前記光学装置は、前記複数の室を所定数ずつ少なくとも２つのグループに区分し、区分されたグループごとにそれぞれ前記ガスの供給口と排出口を設け、前記供給口と排出口にはそれぞれ開閉弁を設けて構成したことを特徴とする投影露光装置。

３０．マスクのパターンを基板上に転写する露光装置において、

照明ビームを射出する光源と前記基板との間に配置される光学系と、

光学素子を保持する鏡筒の少なくとも一端に保護フィルタが配置され、前記鏡筒内に前記照明ビームの吸収が少ない気体が充填された光学ユニットとを備え、

前記光学ユニットが前記光学系内に配置されることを特徴とする露光装置。

３１．前記光学系は、前記照射ビームを前記マスクに照射する照明光学系を含み、前記光学ユニットは前記照明光学系内に配置されることを特徴とする請求項３０に記載の露光装置。

３２．前記光学系への前記光学ユニットの取付時に、前記保護フィルタは前記鏡筒から取り外されるか、又は別の保護フィルタと交換されることを特徴とする請求項３０又は３１に記載の露光装置。

３３．前記光学系内に前記照明ビームの吸収が少ない気体を供給する気体供給装置を更に備え、前記光学系内に前記気体を充填した状態で前記照明ビームを通した後に前記気体供給装置を動作させることを特徴とする請求項３０乃至３２のいずれか一項に記載の露光装置。

３４．前記光学系内の気体を排出する排気装置を更に備え、前記光学系内に前記気体を充填又は供給する前に前記排気装置を動作させることを特徴とする請求項３３に記載の露光装置。

３５．マスクのパターンを基板上に転写する露光装置において、

照明ビームを射出する光源と前記基板との間に配置される光学系と、

前記光学系の少なくとも一部に、前記照明ビームの吸収が少ない気体を供給する気体供給装置と、

前記気体の供給に先立って前記少なくとも一部から気体を排出する排気装置とを備えたことを特徴とする露光装置。

３６．前記光学系は、前記照明ビームを前記マスクに照射する照明光学系と、前記光源と前記照明光学系との間に配置される送光系と、前記マスクから出射する照明ビームを前記基板上に投影する投影光学系とを含むことを特徴とする請求項３５に記載の露光装置。

３７．前記照明ビームの照射による前記光学系の光洗浄後に、前記排気装置と前記気体供給装置とを順次動作させることを特徴とする請求項３５又は３６に記載の露光装置。

３８．前記照明ビームの波長は１００乃至２００ｎｍの範囲内であることを特徴とする請求項３０又は３５に記載の露光装置。

３９．前記照明ビームはＡｒＦエキシマレーザ、又はF_2レーザであり、前記気体は窒素、又はヘリウムであることを特徴とする請求項３８に記載の露光装置

４０．マスクを介して照明ビームで基板を露光する装置の製造方法において、

光学素子を保持する鏡筒の少なくとも一端に保護フィルタを配置して、前記鏡筒内に前記照明ビームの吸収が少ない気体を充填し、

前記照明ビームを射出する光源と前記基板との間に前記鏡筒を配置することを特徴とする露光装置の製造方法。

４１．前記鏡筒の配置後、前記保護フィルタを取り外すか、又は前記保護フィルタを別の保護フィルタに交換することを特徴とする請求項４０に記載の露光装置の製造方法。

４２．マスクを介して照明ビームで基板を露光する装置の製造方法において、

前記照明ビームを通す光学系の少なくとも一部に洗浄光を照射し、

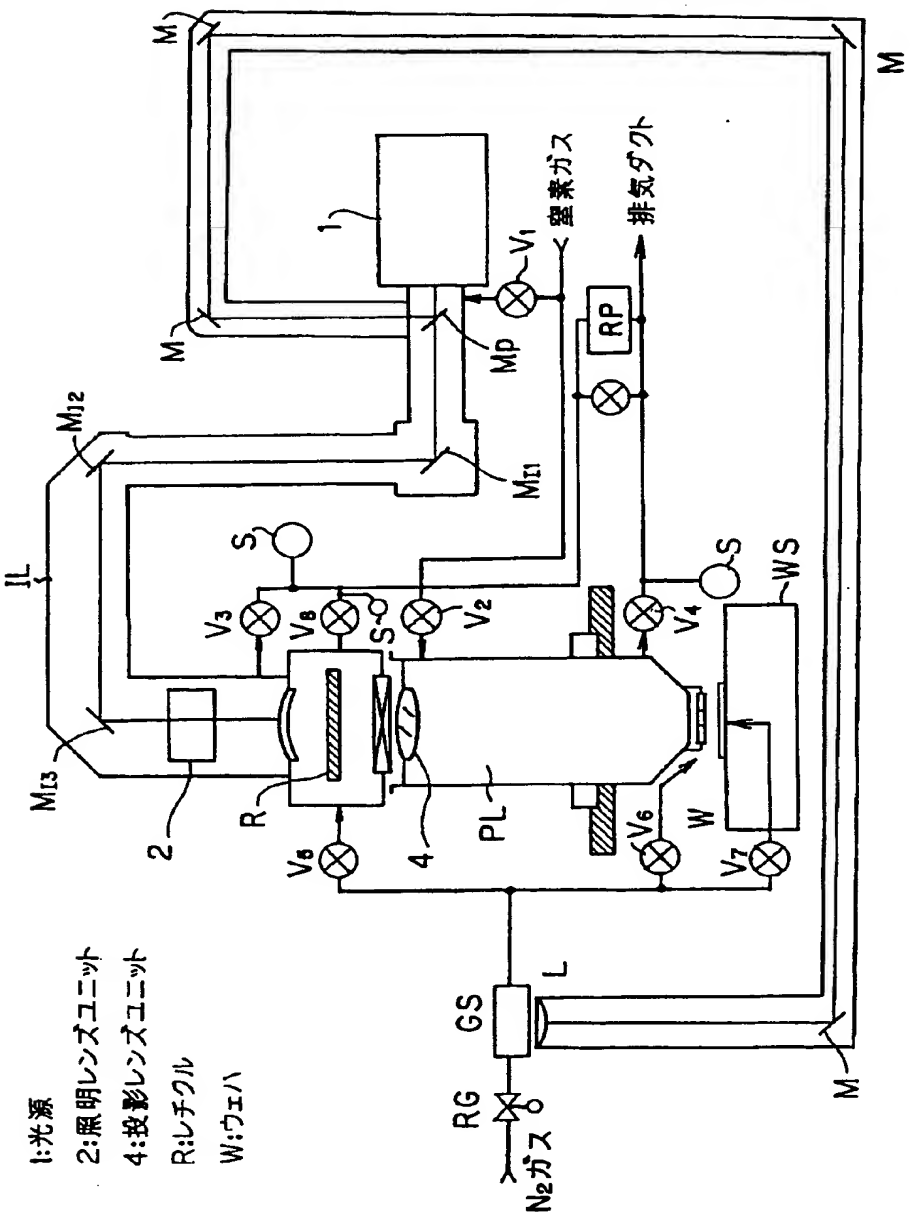
前記光学系内の気体を、前記照明ビームの吸収が少ない気体に置換することを特徴とする露光装置の製造方法。

４３．前記照明ビームの吸収が少ない気体を前記光学系に供給する前に、前記光学系内の気体を排出することを特徴する請求項４２に記載の露光装置の製造方法。

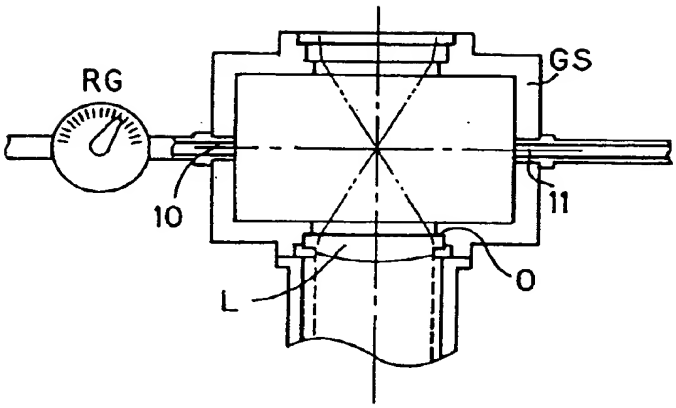
４４．前記洗浄光の照射前に、前記照明ビームの吸収が少ない気体を前記光学系に供給しておくことを特徴とする請求項４２又は４３に記載の露光装置の製造方法。

４５．前記洗浄光は前記照明ビームであり、前記光学系は、前記照明ビームを前記マスクに照射する照明光学系と、前記マスクから出射する照明ビームを前記基板上に投影する投影光学系とを含むことを特徴とする請求項４２乃至４４のいずれか一項に記載の露光装置の製造方法。

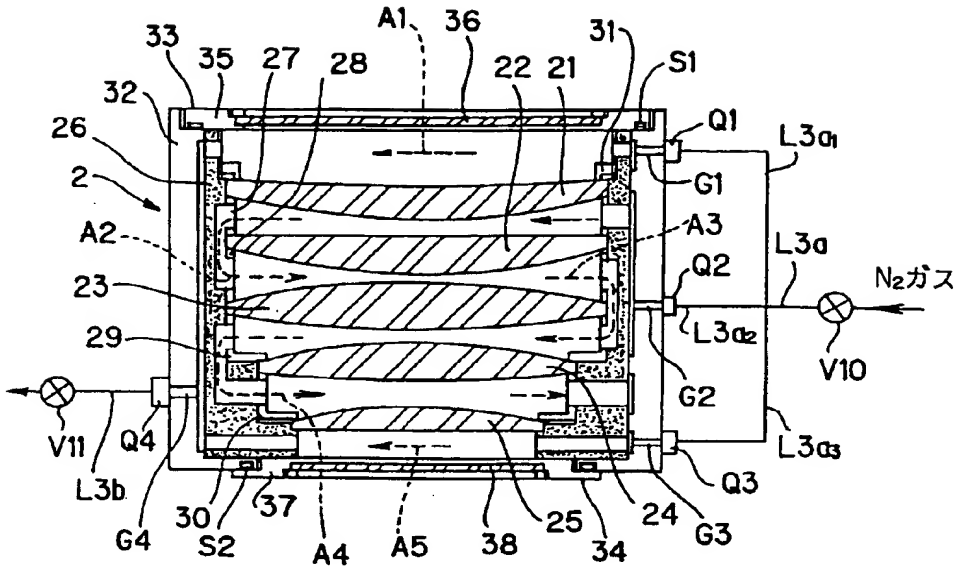
【図 1】


M
M
M
M
1
窒素ガス
排気ダクト
V1
RP
Mp
M12
M11
IL
S
V3
V8
S
V2
V4
S
WS
M13
2
R
V8
4
PL
V6
W
V7
L
GS
RG
N2ガス
1:光源
2:照明レンズユニット
4:投影レンズユニット
R:レチクル
W:ウェハ

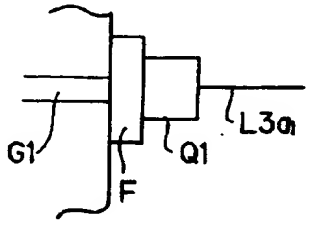
【図 2】



【図 3】

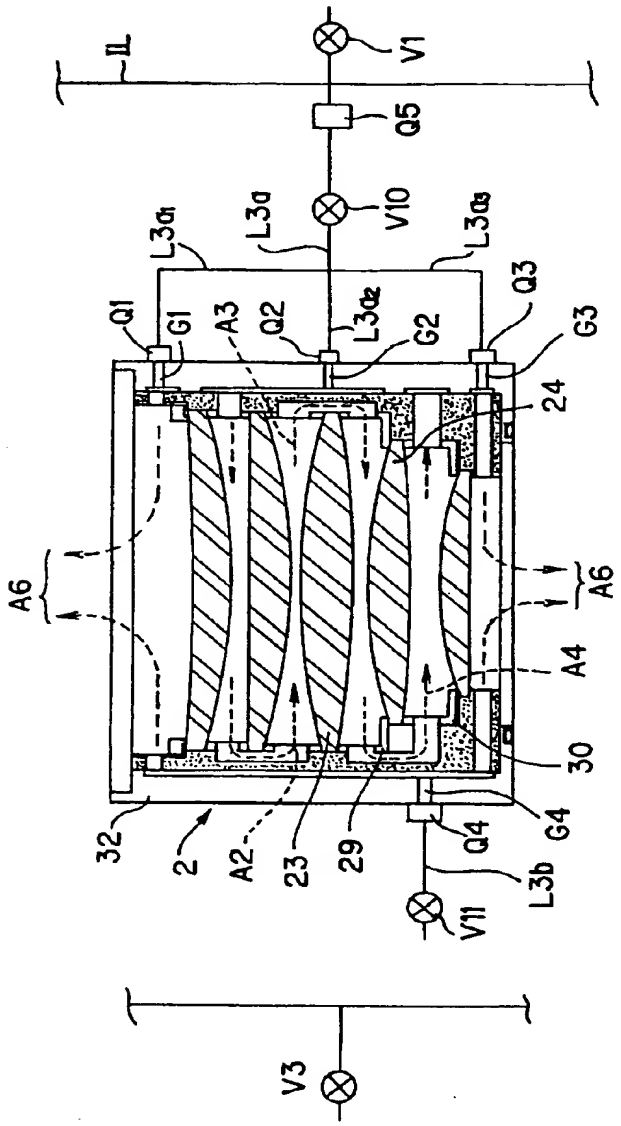

A1
36
31
33
35
27
28
22
21
S1
32
Q1
L3a1
26
G1
2
A2
A3
L3a
Q2
N2ガス
23
L3a2
29
V10
G2
V11
Q4
L3a3
Q3
L3b
30
37
25
24
G4
S2
A4
A5
38
34
G3

(a)

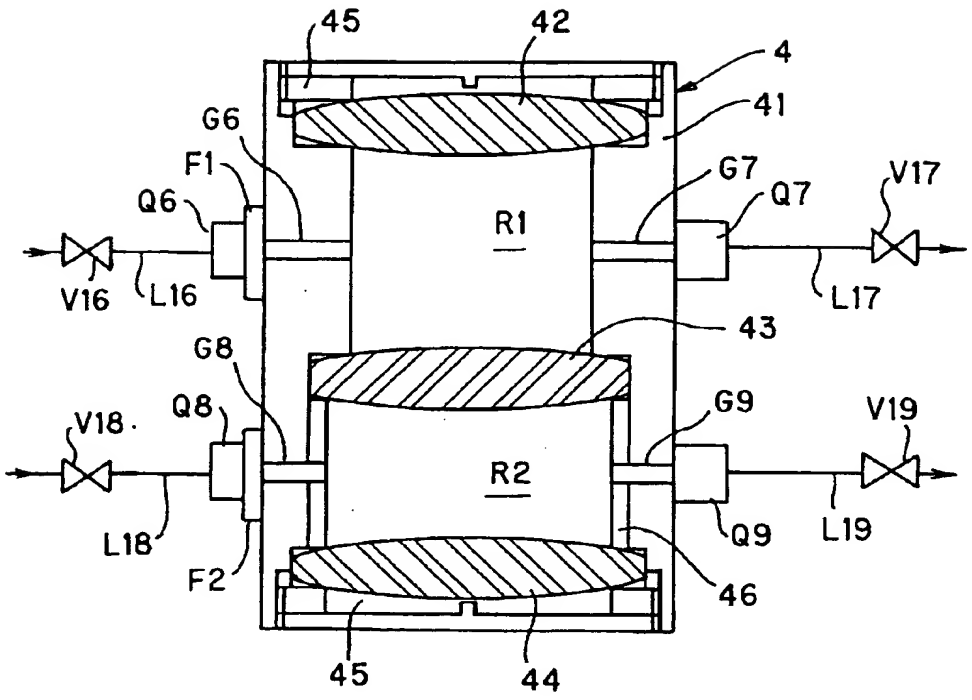

G1
L3a1
Q1
F

(b)

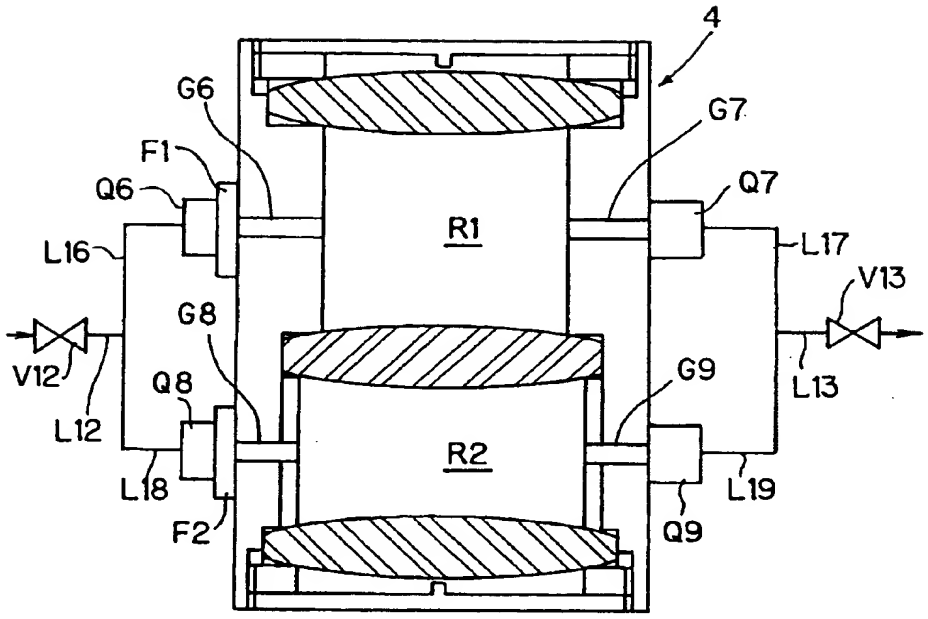
【図 4】


IL
V1
Q5
V10
L3a
L3a1
L3a2
L3a3
Q1
G1
A3
Q2
G2
Q3
G3
24
A6
A6
A4
30
32
2
A2
23
29
Q4
G4
L3b
V11
V3

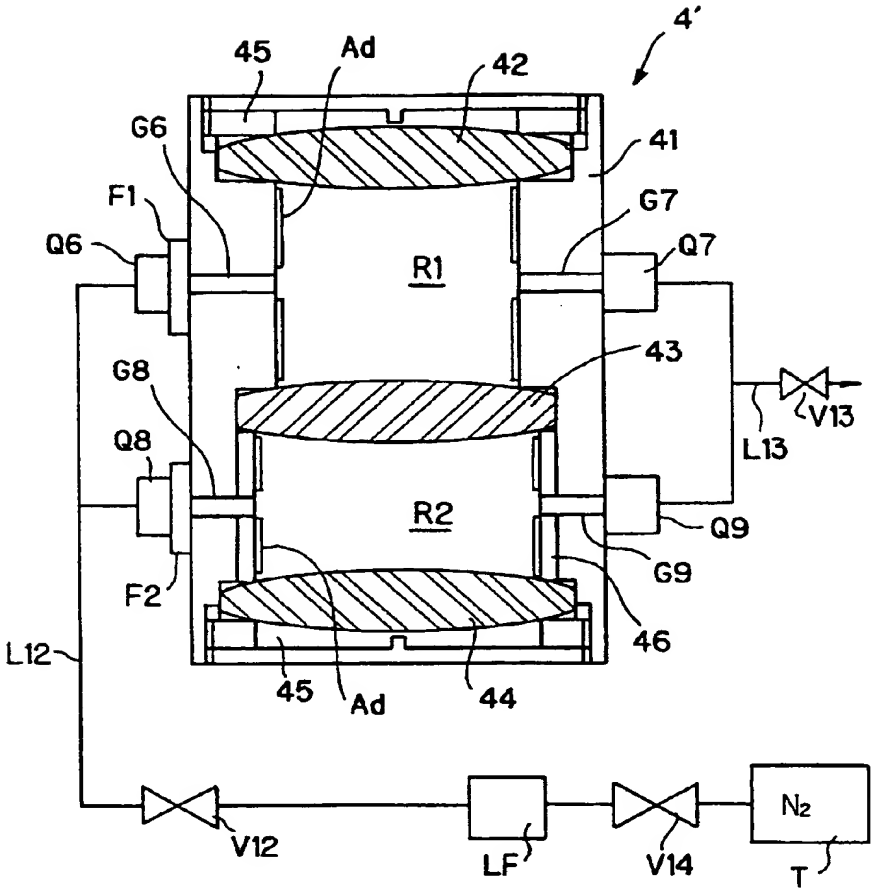
【図 5】


45
42
4
41
G6
F1
Q6
R1
G7
Q7
V17
V16
L16
L17
43
G8
Q8
V18
G9
V19
R2
L18
F2
Q9
L19
46
45
44

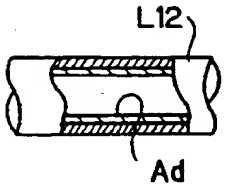
【図 6】



【図 7】


4'
45
Ad
42
G6
41
F1
G7
Q6
R1
Q7
43
G8
V13
Q8
L13
R2
Q9
G9
F2
46
L12
45
Ad
44
V12
LF
V14
N2
T

【図 8】


L12
Ad

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/02536

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] G02B27/00, H01L21/30, G03F7/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] G02B27/00, H01L21/30, G03F7/20, B08B7/00, H01S3/00-3/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1950-1998
Kokai Jitsuyo Shinan Koho 1971-1995

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 03-155611, A (Seiko Epson Corp.),	35
Y	3 July, 1991 (03. 07. 91) (Family: none)	1-3, 6-19, 30-34, 36-45
A		4, 5, 20-29
Y	JP, 03-154390, A (Mitsubishi Electric Corp.),	1-3, 6-19, 30-45
A	2 July, 1991 (02. 07. 91) (Family: none)	4, 5, 20-29
Y	JP, 08-055792, A (Canon Inc.), 27 February, 1996 (27. 02. 96) (Family: none)	7, 36, 37
Y	JP, 08-509652, A (Cauldron Limited Partnership), 15 October, 1996 (15. 10. 96)	8-15, 37, 42-45
A	& WO, 94/23854	21-29

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
18 August, 1998 (18. 08. 98)

Date of mailing of the international search report
25 August, 1998 (25. 08. 98)

Name and mailing address of the ISA/
Japanese Patent Office

Facsimile No.

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

国際調査報告

国際出願番号　PCT／JP98／02536

A.　発明の属する分野の分類（国際特許分類（IPC））
Int. Cl 6　G02B27／00,　H01L21／30,　G03F7／20

B.　調査を行った分野
調査を行った最小限資料（国際特許分類（IPC））
Int. Cl 6　G02B27／00,　H01L21／30,　G03F7／20,
B08B7／00,　H01S3／00－3／30

最小限資料以外の資料で調査を行った分野に含まれるもの
日本国実用新案公報　1950－1998
日本国公開実用新案公報　1971－1995

国際調査で使用した電子データベース（データベースの名称、調査に使用した用語）

C.　関連すると認められる文献

引用文献のカテゴリー＊	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求の範囲の番号
X Y	JP，03－155611，A（セイコーエプソン株式会社），03．7月．1991（03．07．91）（ファミリーなし）	35 1-3,6-19,30-34,36-45
A		4,5,20-29
Y	JP，03－154390，A（三菱電機株式会社），02．7月．1991（02．07．91）（ファミリーなし）	1-3,6-19,30-45
A		4,5,20-29
Y	JP，08－055792，A（キャノン株式会社），27．2月．1996（27．02．96）（ファミリーなし）	7,36,37

☒ C欄の続きにも文献が列挙されている。　☐ パテントファミリーに関する別紙を参照。

＊　引用文献のカテゴリー
「A」特に関連のある文献ではなく、一般的技術水準を示すもの
「E」先行文献ではあるが、国際出願日以後に公表されたもの
「L」優先権主張に疑義を提起する文献又は他の文献の発行日若しくは他の特別な理由を確立するために引用する文献（理由を付す）
「O」口頭による開示、使用、展示等に言及する文献
「P」国際出願日前で、かつ優先権の主張の基礎となる出願の日の後に公表された文献
「T」国際出願日又は優先日後に公表された文献であって出願と矛盾するものではなく、発明の原理又は理論の理解のために引用するもの
「X」特に関連のある文献であって、当該文献のみで発明の新規性又は進歩性がないと考えられるもの
「Y」特に関連のある文献であって、当該文献と他の1以上の文献との、当業者にとって自明である組合せによって進歩性がないと考えられるもの
「&」同一パテントファミリー文献

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SPECIFICATION

OPTICAL DEVICE, METHOD OF CLEANING THE SAME, PROJECTION ALIGNER, AND METHOD OF PRODUCING THE SAME

TECHNICAL FIELD

The present invention relates to an exposure apparatus and a method for manufacturing the same, which has an excimer laser light source, a higher harmonics laser light source, a mercury lamp light source or the like, each radiating light having an ultraviolet range of a wavelength of, for example, 300 nm or shorter. The present invention also relates to an optical device for a projection optical system or an illumination optical system for use with such an exposure apparatus, and to a method for cleaning such an optical device.

BACKGROUND OF THE INVENTION

An exposure apparatus for exposing an image of a pattern of a reticle (a photomask or the like) onto a photosensitive substrate through a projection optical system has been employed in a lithography process for manufacturing semiconductor elements, liquid crystal substrates, and so on. Recent years, developments have been performed to make semiconductor integrated circuits finer and finer, and in order to comply with such finer integration of semiconductor circuits, there has been attempted to make shorter an exposing wavelength of a light source for use in a lithography process.

At a current time, an exposure apparatus has already been developed which uses a KrF excimer laser having a

wavelength of 248 nm as a light source for a stepper. For example, a higher harmonic wave of a wavelength variable laser such as Ti-sapphire laser, etc., a quadruple harmonic wave of a YAG laser having a wavelength of 266 nm, a fivefold harmonic wave of a YAG laser having a wavelength of 213 nm, a mercury lamp having a wavelength close to 220 nm or a wavelength of 184 nm, and an ArF excimer laser having a wavelength of 193 nm draw attention as a candidate for a light source having a shorter wavelength.

For conventional exposure apparatuses which use g-rays, i-rays, a KrF excimer laser, or a mercury lamp emitting light rays having a wavelength close to 250 nm as a light source, emission spectral rays of such a light source do not overlap with an absorption spectral region of oxygen, so that they do not cause any decrease in efficiency of light utilization due to absorption of oxygen and do not suffer from any disadvantage resulting from the generation of ozone due to the absorption of oxygen. Therefore, those exposure apparatuses can basically be used for exposure in ambient atmosphere.

On the other hand, however, for a light source such as an ArF excimer laser, emission spectral rays overlap with an absorption spectral region of oxygen, so that a decrease in efficiency of light utilization may be caused by the adsorption of oxygen, and the disadvantage may also result from the generation of ozone due to the absorption of oxygen. For instance, if it is supposed that a transmittance of an ArF excimer laser light in vacuum or

through an inert gas such as nitrogen or helium is 100%/m, the transmittance is decreased to approximately 90%/m, on the one hand, when the light is in a free-run state, i.e., in a natural emission state, that is, the light source is an ArF broad-banded laser, and it is decreased to approximately 98%/m, on the other hand, even when there is used an ArF laser with the spectral width narrowed and so narrow-banded as to avoid rays of absorption of oxygen.

It is considered that the decrease in transmittance is caused due to the absorption of light by oxygen and an influence of ozone generated. The generation of ozone is considered to exert an adverse influence upon the transmittance of light (i.e., efficiency of light utilization) as well as to cause a deterioration in performance of devices due to a reaction with a surface of an optical material or other parts and to cause a pollution of environment.

For the above-mentioned conventional exposure apparatuses having a light source such as an ArF excimer laser in the configuration as described above, it is well known that the entire area of a light passage is required to be filled with an inert gas such as nitrogen or the like, in order to avoid a decrease in transmittance of light and a generation of ozone.

As a result of various exposure experiments using a projection exposure apparatus with an excimer laser light source installed therein and having a relatively large field size, a new phenomenon has now been discovered in

that the irradiation of an illuminating light in an ultraviolet region having a wavelength range of, for example, 350 nm or less (e.g., KrF excimer laser having a wavelength of 248 nm or ArF excimer laser having a wavelength of 193 nm, etc.) dynamically fluctuates transmittance or reflectance of an optical element in a projection optical system or a coating material (e.g., a thin film for a reflection preventive film, or the like) for the optical element in the projection optical system. It is further found that this new phenomenon fluctuating the transmittance of light dynamically can be caused to occur in substantially the same way as not only in the case of an optical element disposed in the projection optical system but also in the case of an optical element disposed in an illumination optical system for illuminating a reticle. Moreover, likewise, it is also found that the such phenomenon is caused to occur in the case of an optical element in a light sending system leading the illuminating light leaving from a light source disposed under a floor of a clean room to an illumination optical system installed in the main body of the exposure apparatus, and in the case of the reticle (a quartz plate) itself.

In addition, the such phenomenon is considered to occur, for instance, due to the attachment of impurities contained in a gas (e.g., air, nitrogen gas, etc.) present in a space of a projection light passage or an illumination light passage, molecules of organic substances departing from adhesive or a filling material, etc., for use in

fixing optical elements to a barrel, impurities (e.g., water molecules, hydrocarbon molecules, or other substances diffusing the illuminating light) derived from the inner wall) derived from an inner wall of the barrel (e.g., a coated surface for reflective prevention, etc.), or otherwise, or due to the entry (floating) of such impurities or otherwise into the illumination light passage. As a consequence, a serious problem is considered to be caused such that the transmittance or reflectance of the projection optical system, the illumination optical system, and the light sending system fluctuates to a great extent for a relatively short period of time.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an optical device which is so arranged as for an optical element including, for example, lenses constituting a projection optical system, an illumination optical system or a light sending system, or a reflecting mirror or otherwise unlikely to be contaminated, to provide a method for cleaning the optical device, to provide an exposure apparatus using such a projection optical system, an illumination optical system or a light sending system, each being unlikely to be contaminated, which has been cleaned by the method for cleaning, and to provide a method for manufacturing the such exposure apparatus.

Further, the present invention has another object to provide an exposure apparatus that can prevent an optical characteristic (for example, transmittance or reflectance)

of an optical member from fluctuating by irradiating the optical member with a radiating beam having a wavelength of, for example, 350 nm or less.

Moreover, the present invention has a further object to provide an exposure apparatus in which an optical member including, for example, an illumination optical system, a projection optical system or a light sending system or otherwise, each being incorporated in the exposure apparatus, is so arranged as to be cleaned.

In order to achieve the object as described above, the optical apparatus according to the present invention is configured in such a manner that a protective filter is disposed apart in a predetermined distance between the optical elements, among plural optical elements disposed in a barrel, which are disposed on the both end sides in the axial direction of the barrel, wherein chambers disposed between the plural optical elements and a space between the optical elements on each of the both end sides and the protective filter is filled with an inert gas in advance.

The optical device according to the present invention is installed in an apparatus for irradiating a mask with an illuminating light and exposing a substrate with the illuminating light through the mask, wherein an inert gas having the lower capability of absorbing the illuminating light is used as the inert gas to be filled therein. The illuminating light to be used therefor has a wavelength of 350 nm or less. Further, upon mounting the optical device on a light passage housing of the illumination optical

system installed in the exposure apparatus, it is preferred that the protective filter is detached while the space is being purged with the gas and then the housing is filled with the inert gas, or that the protective filter is detached while the space is being purged with the gas and a fresh protective filter cleaned in advance is mounted on the both sides in an axial direction of the barrel, followed by filling the light passage with the inert gas.

In order to achieve the objet as described above, the present invention according to another embodiment provides the optical device comprising a gas supply passage for supplying an inert gas to a barrel with a plurality of optical elements disposed therein; an supply inlet connected to the gas supply passage; a gas discharge outlet for discharging the inert gas present in the barrel; and a removing member for removing a contaminating material, disposed on an inner wall of the gas supply passage.

The optical device according to the another embodiment of the present invention is installed in a device for irradiating a mask with an illuminating light and exposing a substrate with the illuminating light through the mask, wherein a gas having a lower capability of absorbing the illuminating light is used as the inert gas. As the removing member, there may be used an adsorbing material or a filter.

In order to achieve the object as described above, the present invention according to a further embodiment provides an optical device for use with an exposure

apparatus for transferring a pattern on a mask onto a substrate, in which the removing member for removing a contaminating material is mounted on an inner surface of a barrel with a plurality of optical elements disposed therein.

Further, in order to achieve the object as described above, the present invention provides the optical device according to a still further embodiment so adapted as to be used for an exposure apparatus that transfers a pattern on a mask onto a substrate by irradiating the mask with an illuminating light, wherein each of plural chambers formed between the plurality of the optical elements disposed in the barrel is provided with a gas supply inlet and a gas discharge outlet, respectively, for supplying and discharging an inert gas having a less capability of absorbing the illuminating light, and each of the gas supply inlet and the gas discharge outlet is provided with an opening-closing valve for opening and closing the gas supply inlet and the gas discharge outlet, respectively.

In addition, in order to achieve the object as described above, the present invention in another aspect provides a light cleaning method for cleaning the optical device for use with an exposure apparatus for transferring a pattern on a mask onto a substrate by irradiating the mask with an illuminating light, the optical device being configured in such a way that each of chambers formed between a plurality of optical elements disposed in a barrel is provided with a gas supply inlet and a gas

discharge outlet for supplying and discharging a gas having a lesser capability of absorbing the illuminating light, respectively, and that the gas supply inlet and the gas discharge outlet are each provided with an opening-closing valve for opening and closing the gas supply inlet and the gas discharge outlet, respectively; wherein the optical device is cleaned by the light cleaning method comprising the step for filling the barrel with the gas to a predetermined pressure in such a state that the opening-closing valve of the gas supply inlet is opened while the opening-closing valve of the gas discharge outlet is closed; the step for allowing a contaminating material attached on a surface of the optical elements to float by irradiating the optical elements with the illuminating light in such a state that the opening-closing valves of the gas supply inlet and the gas discharge outlet are both closed; the step for flowing the gas outside and inside the barrel by opening the opening-closing valve of the gas supply inlet and the opening-closing valve of the gas discharge outlet; and the step for closing the opening-closing valves of the gas supply inlet and the gas discharge outlet, respectively.

With the above configuration, it is also possible to flow the inert gas through each of the plural chambers in such a state that the opening-closing valves of the gas supply inlet and the gas discharge outlet are both opened, prior to closing the opening-closing valve of the gas discharge outlet. Moreover, the optical device may be

configured in such a manner that the plural chambers are divided into at least two groups, each group having a predetermined number of chambers, and each group is provided with a gas supply inlet and a gas discharge outlet as well as the gas supply inlet and the gas discharge outlet are each provided with an opening-closing valve.

Furthermore, in order to achieve the object as described above, the present invention provides a projection exposure apparatus for transferring a pattern on a mask onto a substrate through a projection optical system by irradiating the mask with an illuminating light, wherein a plurality of chambers, each chamber being formed between a plurality of optical elements disposed in a barrel and provided with a gas supply inlet and a gas discharge outlet for supplying and discharging an inert gas having a lesser capability of absorbing the illuminating light, respectively, and the gas supply inlet and the gas discharge outlet being each provided with an opening-closing valve; wherein the optical device is so arranged as to be cleaned by a light cleaning method comprising the step for filling the barrel with the gas to a predetermined level of pressure in such a state that the opening-closing valve of the gas supply inlet is opened while the opening-closing valve of the gas discharge outlet is closed; the step for allowing a contaminating material attached on a surface of the optical elements to float by irradiating the optical elements with the illuminating light in such a state that the opening-closing valves of the gas supply inlet and the

gas discharge outlet are both closed; the step for flowing the gas outside and inside the barrel by opening the opening-closing valve of the gas supply inlet and the opening-closing valve of the gas discharge outlet; and the step for closing the opening-closing valves of the gas supply inlet and the gas discharge outlet, respectively.

The optical device according to the present invention may also be used as the projection optical system and/or the illumination optical system for irradiating the mask with the illuminating light.

In order to achieve the object as described above, the present invention in a further aspect provides an exposure apparatus for transferring a pattern on a mask onto a substrate, which comprises an optical system interposed between a light source for emitting an illuminating beam and the substrate; a protective filter disposed at least at an end of a barrel for holding an optical element; and an optical unit having a gas having a lesser capability of absorbing the illuminating beam filled in the barrel, the optical unit being disposed in the optical system.

With the above configuration, the optical device according to the present invention contains an illumination optical system for irradiating the mask with the illuminating beam and has the optical unit disposed in the illumination optical system. Upon mounting the optical unit on the optical system, the protective filter may be detached from the barrel or a new protective filter is

exchanged for the older one. Preferably, the optical device according to the present invention is further provided with a gas supply device for supplying an inert gas having a lesser capability of absorbing the illuminating beam, which is disposed in the optical system, and the gas supply device is to be operated after the illuminating beam has been emitted in such a state that the optical system is filled with the inert gas. Moreover, it is preferred that the optical device is further provided with a gas exhaust device for discharging the inert gas present in the optical system and that the gas exhaust device is operated prior to filling or supplying the optical system with the inert gas. The illuminating beam to be used therefor may have a wavelength preferably in the range of from 100 nm to 200 nm, and it may preferably include, for example, ArF laser or F_2 laser. Moreover, the inert gas may preferably include, for example, nitrogen, helium, or the like.

In addition, in order to achieve the object as described above, the present invention in a still further embodiment provides the exposure apparatus for transferring a pattern on a mask onto a substrate, which comprises an optical system interposed between a light source for emitting an illuminating beam and the substrate; a gas supply device for supplying an inert gas having a lesser capability of absorbing the illuminating beam to at least a portion of the optical system; and a gas exhaust device for discharging the inert gas from the portion of the optical

system prior to the supply of the inert gas.

With the above configuration, the optical device according to the present invention may contain an illumination optical system for irradiating the mask with the illuminating beam, a light sending system interposed between the light source and the illumination optical system, and a projection optical system for projecting the illuminating beam leaving from the mask onto the substrate. With this configuration, it is preferred that the gas exhaust device and the gas supply device are operated one after another in this order after the optical system has been cleaned by means of light by irradiating the optical system with the illuminating beam. The illuminating beam to be used therefor may have a wavelength preferably in the range of from 100 nm to 200 nm, and it may preferably include, for example, ArF laser or F_2 laser. Moreover, the inert gas may preferably include, for example, nitrogen, helium, or the like.

In order to achieve the object as described above, the present invention in a still further aspect provides a method for the production of the exposure apparatus, which comprises locating a protective filter at least at an end of a barrel holding optical elements, filling the barrel with an inert gas having a lesser capability of absorbing the illuminating beam, and locating the barrel between a light source for emitting the illuminating light and the substrate.

In the method for the production of the exposure

apparatus according to the present invention, the protective filter is detached or a new protective filter is exchanged for the older protective filter, after the barrel has been disposed.

Moreover, in order to achieve the object as described above, the present invention in a still further embodiment provides a method for the production of the exposure apparatus for exposing the substrate to the illuminating beam through the mask, which comprises irradiating at least a portion of the optical system capable of allowing the illuminating beam to pass therethrough with a cleaning light for cleaning the optical system and replacing the gas present in the optical system with a gas having a lesser capability of absorbing the illuminating beam.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

Fig. 1 is a schematic illustration of an exposure apparatus in an embodiment of the present invention.

Fig. 2 is a view showing details of a gas cell GS.

Fig. 3 is a schematic illustration showing an illuminating lens unit 2; in which Fig. 3(a) is a sectional view; and Fig. 3(b) is an enlarged view showing a portion of a quick coupler Q1 of Fig. 2(a).

Fig. 4 is a view for explaining procedures of mounting the illuminating lens unit 2 on an illumination optical system IL.

Fig. 5 is a sectional view showing a projecting lens unit 4.

Fig. 6 is a view showing a first variation of the

projecting lens unit of Fig. 5.

Fig. 7 is a view showing a second variation of the projecting lens unit of Fig. 5.

Fig. 8 is a sectional view showing a tubular path L12 as shown in Fig. 7.

BEST MODE FOR CARRYING OUT THE INVENTION

A description will be made of the embodiment according to the present invention with reference to Figs. 1 to 8.

Fig. 1 is a view for schematically explaining an exposure apparatus according to the embodiment of the present invention. As shown in Fig. 1, a light source 1 for emitting an ArF excimer laser light is disposed separately from a chamber in which the main body of the exposure apparatus is housed. A portion of the light beam leaving from the light source 1 is transmitted through a light sending system, that is, a beam splitter (a partial mirror) Mp to a mirror M_{I1} while the remaining is reflected and then travels toward a mirror M. The light passed through the beam splitter Mp is reflected at mirrors M_{I1} and M_{I2} in the light sending system and at a mirror M_{I3} in an illumination optical system IL, thereby illuminating a reticle R in a uniform manner through an illuminating lens unit 2 disposed in the illumination optical system IL. Fig. 1 shows an integral combination of the light sending system and the illumination optical system IL. In Fig. 1, only one illuminating lens unit 2 is shown, although in usual cases the illumination optical system IL comprises a

plurality of illuminating lens units 2 (containing, e.g., a flyeye lens unit, a relay lens unit, a condenser lens unit, etc.). The light sending system and the illumination optical system IL are enclosed with a container, and the container is supplied with a gas having no or a lesser capability of absorbing an ArF light, such as, for example, nitrogen gas (or helium gas), through a valve V1. Although not shown, the reticle R is loaded on a stage and allowed to be transferred relatively to the illuminating light leaving through a slit or otherwise of a vision field stop of the illumination optical system IL.

The light passed through the reticle R is transmitted through a variety of optical members constituting an projection optical system PL, e.g., a lens element and/or a mirror, onto the surface of a wafer W loaded on a wafer stage WS, and a pattern formed on the reticle R is imaged on the surface of the wafer W. The wafer stage WS is so arranged as to transfer the wafer W in a direction relative to the light leaving from the reticle R by irradiating it with the illuminating light and passing through the projection optical system PL. Upon exposure, the reticle R and the wafer W are scanned in directions opposite to each other at a velocity ratio corresponding to a magnification of the projection optical system. The projection optical system PL is provided with at least one projecting lens unit 4, and the projection optical system PL is enclosed with a container in substantially the same manner as the illumination optical system IL. The container is supplied

with a nitrogen gas or otherwise through a valve V2. The details of the illuminating lens unit 2 and the projecting lens unit 4 will be described hereinafter.

The container for enclosure of the illumination optical system IL is provided with a valve V3 for discharging nitrogen gas therefrom, and the nitrogen gas discharged from the valve V3 is sent to an exhaust duct by the aid of a rotary pump RP. The container is also provided with a valve V4 for discharging nitrogen gas therefrom, and the nitrogen gas discharged through the valve V4 is then supplied to an exhaust duct through the rotary pump RP. The light left from the light source 1 and reflected at the beam splitter Mp is then reflected by means of a plurality of mirrors M disposed and arranged in an appropriate manner, and enters into a gas cell GS through a lens L. The gas cell GS is supplied with nitrogen gas through a pressure reducing valve RG. As shown in Fig. 2, the gas cell GS is provided with an orifice O, and the lens L is disposed so as to seal the orifice O. The light entering into the gas cell GS through the lens L is so arranged as to be focused on an axis connecting a gas supply inlet 10 to a gas discharge outlet 11. The nitrogen gas is ionized in the gas cell GS by the two-photon absorption action of ultraviolet light.

The ionized nitrogen gas discharged from the gas cell GS is divided into three paths, each being supplied to a container enclosing the reticle R and a reticle stage through a valve V5, to a bottom end portion of the

projection optical system PL through a valve V6, and to the wafer WS through a valve V7. The container for enclosing the reticle R and the reticle stage is provided with a valve V8 through which the nitrogen gas is discharged. The nitrogen gas discharged through the valve V8 is supplied to an exhaust duct through an oxygen sensor S and the rotary pump RP.

--Detailed Description of Illuminating Lens Unit--

Fig. 3(a) is a view in section of the illuminating lens unit 2 disposed in the illumination optical system IL. A barrel 26 has lenses 21 to 25, inclusive, and lens separation rings 27 to 30, inclusive, disposed each so as to hold the lenses in a predetermined distance from one another. Moreover, the lenses and the lens separation rings are fixed to the barrel 26 by means of a pressing ring 31. The barrel 26 is housed in a casing 32, and caps 33 and 34 are mounted on the top and bottom openings (when looked at the drawing) of the casing 32 through O-ring seals S1 and S2, respectively. The cap 33 is configured such that a glass member 36 is mounted on a frame 35, and the cap 34 is configured such that a glass member 38 is mounted on a frame 37. The casing 32 is provided with a tubular path L3a for supplying nitrogen gas and a tubular path L3b for discharging the nitrogen gas, and the tubular paths L3a and L3b are provided with valves V10 and V11, respectively. The tubular path L3a for the supply of the gas is divided into three tubular path divisions $L3a_1$, $L3a_2$ and $L3a_3$, the tubular path division $L3a_1$ being connected to

a gas supply inlet G1 through a quick coupler Q1, the tubular path division $L3a_2$ being connected to a gas supply inlet G2 through a quick coupler Q2, and the tubular path division $L3a_3$ being connected to a gas supply inlet G1 through a quick coupler Q3. On the other hand, the tubular path L3b is connected to a gas discharge outlet G4 through a quick coupler Q4.

Fig. 3(b) is an enlarged view of the portion of the quick coupler Q1 of the tubular path division L3a1. As shown in Fig. 3(b), a chemical filter F is disposed on the downstream side of the quick coupler Q1 so as to prevent a contaminating material from entry into the casing 32. Likewise, the other tubular path divisions $L3a_2$ and $L3a_3$ are provided each with a chemical filter F. A description will be made of the chemical filter F hereinafter.

As the nitrogen gas has been supplied from the tubular path L3a, the nitrogen gas supplied to the gas supply inlet G1 through the tubular path division $L3a_1$ is flown through a lens chamber interposed between the cap 33 and the lens 21 in the direction as indicated by the arrow A1, and the nitrogen gas is then discharged through the gas discharge outlet G4 into the tubular path L3b. On the other hand, the nitrogen gas supplied to the gas supply inlet G2 through the tubular path division $L3a_2$ is allowed to flow through a lens chamber interposed between the lenses 21 and 22 and then through a lens chamber interposed between the lenses 22 and 23 in the direction as indicated by the arrow A2, followed by passing through a lens chamber

interposed between the lenses 23 and 24 in the direction as indicated by the arrow A3, and through a lens chamber interposed between the lenses 24 and 25 in the direction as indicated by the arrow A4, then followed by discharging the nitrogen gas through the gas discharge outlet G4 to the tubular path division L3b. Further, the nitrogen gas supplied to the gas supply inlet G3 through the tubular path $L3a_3$ is allowed to pass through a lens chamber interposed between the cap 34 and the lens 25 in the direction as indicated by the arrow A5 and then discharged through the gas discharge outlet G4 to the tubular path L3b.

The barrel 26 is assembled in ambient atmosphere in usual cases, so that attachment of a contaminating material to the surfaces of the lenses 21 to 25 is inevitable. In accordance with the present invention, however, the illuminating lens unit 2 is configured such that the contaminating material attached to each of the lenses 21 to 25 can be removed easily and readily in a way as will be described hereinafter and further that attachment of such a contaminating material to the surface of a lens can be avoided upon assembly of the illuminating lens unit 2 with the illumination optical system IL.

More specifically, first, the casing 32 is exhausted in a vacuum state by opening the valve V11 in such a state that the valve V10 is closed. Thereafter, the valve V11 is closed and the valve V10 is opened to supply the casing 32 with nitrogen gas and fill the casing 32 with the nitrogen gas. In this state, each of the lenses 21 to 25, inclusive,

is irradiated with ArF light through a glass member of the cap 33. As the lenses are irradiated with the ArF light, then the contaminating material attached on the surface of each of the lenses 21 to 25 and an inner surface of each of glass members 36 and 38 is allowed to be removed therefrom and to float in the nitrogen gas. While the lenses are irradiated in the manner as described above, the valve V11 is opened and the nitrogen gas present in the casing 32 is allowed to be discharged, thereby resulting in discharging the contaminating material floating in the nitrogen gas outside the casing 32. Then, the valve V11 is closed in the state in which the casing 32 is supplied with the nitrogen gas, and the pressure in the casing 32 is adjusted so as to reach a predetermined level. As the pressure has reached the predetermined level, then the valve V10 is closed, and the illuminating lens unit 2 is stored in this state. Alternatively, unlike in the above-mentioned state in which the casing 32 is filled with the nitrogen gas, the contaminating material may also be removed by irradiating the illuminating lens unit 2 with ArF light or light beams having wavelengths of 185 nm and 254 nm, emitting from a low-pressure mercury lamp, while keeping the nitrogen gas flowing. In the latter case where the low-pressure mercury lamp is used, the low-pressure mercury lamp is arranged in a row with the light source 1 and the light beam emitting from the low-pressure mercury lamp is led to the light sending system by means of a lens and/or a mirror. In this case, however, the optical system disposed behind the low-

pressure mercury lamp and the light source may also be used in substantially the same manner as described above.

With the configuration as described above, the contaminating material attached to the surfaces of the lenses 21 to 25 can be removed easily and readily upon assembly of the barrel 26. Moreover, this manner can avoid the contamination of the lenses 21 to 25 until the illuminating lens unit 2 is assembled with the illumination optical system IL.

Then, a description will be made of the procedures of the assembly of the illuminating lens unit 2 with the illumination optical system IL with reference to Fig. 4. First, the illumination optical system IL is wide open to ambient atmosphere, and the tubular path L3a of the illuminating lens unit 2 is connected to a nitrogen gas supply line of the valve V1 disposed in the illumination optical system IL. Then, the valves V1 and V10 are opened and the valve V11 is closed to supply the casing 32 with the nitrogen gas. Further, after the caps 33 and 34 (see Fig. 3) are detached while the nitrogen gas has been supplied, the valve V11 is opened and the illumination optical system IL is closed. At this time, the nitrogen gas is allowed to flow in each of the lens chambers in the direction as indicated by the respective arrows A1 to A4, inclusive, and the nitrogen gas to be supplied through the tubular paths L3a and L3b is allowed to flow in the direction as indicated by the arrow A6, so that the surface on the opening side of each of the lenses 21 and 25 is

blocked from the open atmosphere by the nitrogen gas. In this configuration, the contamination of the lenses 21 to 25 can be prevented even upon assembly of the illuminating lens unit 2 with the illumination optical system IL.

As will be described hereinafter, the illumination optical system IL is exhausted in a vacuum state through the valve V3 after the assembly of the illuminating lens unit 2 with the illumination optical system IL, and the nitrogen gas is supplied to the illuminating lens unit 2 through the valve V1. At this time, the nitrogen gas supplied to the tubular path L3a through the quick coupler Q5 is allowed to flow into the illumination optical system IL after circulation through the illuminating lens unit 2 and discharged toward the outside through the valve V3. Although the caps 33 and 34 have been detached upon assembly of the illuminating lens unit 2 with the exposure apparatus in the manner as described above, the such assembly can also be made in some device configuration without detaching the caps 33 and 34. In such a case, as the surface on the atmospheric side of each of the glass members 36 and 38 of the respective caps 33 and 34 is contaminated with water or otherwise, the contaminating material can be removed thoroughly from the illuminating lens unit 2, for instance, simply by exchanging new caps non-contaminated for the old caps 33 and 34. It is further to be noted herein that the method for removing the contaminating material by supplying the nitrogen gas and irradiating the illuminating lens unit 2 with the

illuminating light in the manner as described above can also be applied to the projecting lens unit 4, without limiting to the illuminating lens unit 2.

--Description of the Details of the Projecting Lens Unit 4--

Fig. 5 is a view in section of an outline of the projecting lens unit 4 to be disposed in the projection optical system PL. A barrel 41 of the projecting lens unit 4 has three lenses 42, 43 and 44 disposed in a relationship spaced apart in a predetermined distance from one another, and fixed thereto by means of a pressing ring 45. Reference numeral 46 denotes a lens separation ring for holding the lenses 43 and 44 apart in a predetermined distance from each other. It should be noted herein, however, that although the projecting lens unit 4 is provided with a number of lenses in an actual case, Fig. 5 shows only three lenses for brevity of explanation. A lens chamber R1 is formed between the lenses 42 and 43, and a lens chamber R2 is formed between the lenses 43 and 44. The lens chamber R1 is provided with a gas supply inlet G6 having a quick coupler Q6 mounted thereon and with a gas discharge outlet G7 having a quick coupler Q7 mounted thereon. On the other hand, the lens chamber R2 is provided with a gas supply inlet G8 having a quick coupler Q8 mounted thereon and with a gas discharge outlet G9 having a quick coupler Q9 mounted thereon. Between the gas supply inlet G6 and the quick coupler Q6 is interposed a chemical filter F1. Likewise, between the gas supply inlet G8 and the quick coupler Q8 is interposed a chemical filter

F2. The chemical filters F1 and F2 are disposed with the attempt to remove impurities such as, for example, organic substances and alcohols, present in the nitrogen gas to be supplied.

Now, a description will be made of details of the chemical filter. As a filter for removing ions, there may be used, for example, an ion exchange resin, an ion exchange fiber, or the like. As a filter for use in treating gases, an ion exchange fiber is preferred in terms of a larger surface area, a higher reaction velocity, and easiness of processing. Such an ion exchange fiber may be prepared by graft polymerization of a polymer fiber such as, for example, polypropylene fiber, by means of radiation. The ion exchange fiber may be divided into two groups, i.e., an acidic cation exchange fiber and a basic anion exchange fiber. An acidic cation exchange fiber may be preferably used for an positive ion such as, for example, NH_4^+ or an amine ion, or a basic gas, and a basic anion exchange fiber may be preferably used for a negative ion such as, for example, SO_4^{2-} or NOx, or an acidic gas.

Fig. 5 shows the quick couplers Q6 to Q9 having valves V16 to V19 mounted on tubular paths L16 to L19 thereof, respectively, in order to control a flow of the gas to be supplied through each of the gas supply inlets G6 and G8 for each of the lens chambers R1 and R2, respectively. In the case of the projecting lens unit 4, too, it is inevitable that a contaminating material is attached to surfaces of the lenses 42 to 44, inclusive,

upon assembly of a barrel thereof, likewise in the case of the illuminating lens unit 2 in the manner as described above. In this case, too, such a contaminating material attached to the surfaces of the lenses for the projecting lens unit 4 can also be removed in substantially the same procedures as in the case of the illuminating lens unit 2, i.e., by irradiating the projecting lens unit 4 with ArF light while flowing nitrogen gas through the gas supply inlets G6 and G8. A description of the specific procedures for removing such a contaminating material from the projecting lens unit 4 will be omitted from the following explanation because they are substantially the same as in the case of the illuminating lens unit 2.

In the embodiment as shown in Fig. 5, the tubular paths L16 and L19, inclusive, are provided each with a valve so as to control a flow of a gas for each of the lens chambers R1 and R2. It should be noted herein, however, that, as long as a flow amount of a gas that flows through the lens chambers R1 and R2 is not reduced to an extremely low extent, tubular paths L16 and L18 are combined into one tubular path L12, on the one hand, and tubular paths L17 and L19 are combined into one tubular path L13, on the one hand, and the combined tubular paths L12 and L13 are provided with valves V12 and V13, respectively, as shown in Fig. 6, in order to control a flow of the gas through the projecting lens unit 4. Although Fig. 6 shows only three lenses for the projecting lens unit 4 and only one lens chamber for collectively discharging the gas therefrom, the

projecting lens unit 4 is actually provided with a number of lenses so that a plurality of lens chambers are formed. Therefore, in such a case, the number of the lens chambers for collectively discharging the gas for a plurality of lenses may be two or more. A gas supply inlet and a gas discharge outlet are provided for each of the lens chambers as shown in Figs. 5 and 6, however, a line may be provided only for a lens chamber that can be expected to achieve the highest effect from the design point of view.

Fig. 7 shows a variation of the projecting lens unit as shown in Fig. 6, in which the portions and elements identical to those as shown in Fig. 6 are provided with the identical reference numerals and symbols. A description will be made mainly of the portions and elements that differ from those of Fig. 6. As shown in Fig. 7, a projecting lens unit 4' has an inner wall surface of each of the lens chambers R1 and R2 as well as an inner wall surface of the tubular path L12 for supply of a gas coated with an adsorbing material Ad in order to remove water and so on present in a nitrogen gas to be supplied through a nitrogen gas supply source T. The adsorbing material may include, for example, activated carbon, silica gel, zeolite, and so on. In Fig. 7, reference symbol LF sets forth a line filter, and reference symbol V14 sets forth a valve.

Then, a description will be made of the operation of the illuminating lens unit 2 and the projecting lens unit 4, each having the configuration as described above, after they are assembled with the exposure apparatus. Each of

the illumination optical system IL, the projection optical system PL and the reticle R is enclosed with a container from which in turn the air is exhausted into a vacuum state sequentially by the action of the rotary pump RP through the valves V3, V4 and V8, respectively. At this time, the air is discharged from the inside of each of the illuminating lens unit 2 and the projecting lens unit 4 to a vacuum state in the like manner. The degree of vacuum in each of the containers can be known on the basis of the concentration of oxygen to be detected by an oxygen sensor S mounted on each of the respective containers. After the vacuum state has been realized to a predetermined level, the container enclosing each of the illumination optical system IL and the projection optical system PL is supplied with nitrogen gas to a level higher than the atmospheric pressure through the valves V1 and V2, respectively. Further, the container enclosing the reticle R is supplied with an appropriately ionized nitrogen gas to amount to a level higher than the atmospheric pressure through the valve V5. The ionized nitrogen gas can remove static electricity caused to be generated in the reticle R, thereby preventing an occurrence of damages of the reticle R resulting from static electricity.

On the other hand, an ionized nitrogen gas is supplied toward the wafer W in a space between the projection optical system PL and the wafer W through the valve V6 in the direction nearly perpendicular to the wafer W. In addition, an ionized nitrogen gas is further

supplied through the valve V7 so as to block the surface of the wafer W from the open atmosphere. This can remove static electricity generated on the surface of the wafer W by means of the action of the ionized nitrogen gas supplied, thereby preventing the wafer W from being damaged or stained by static electricity.

Upon subjecting the wafer W to projection exposure or exchanging wafers, an ionized nitrogen gas is supplied in a generally continual manner to a space between the projection optical system PL and the wafer W. Therefore, the nitrogen gas atmosphere will not be broken in a substantial manner even upon exchanging wafers. Moreover, only when the reticle R has to be exchanged, it is required that an ionized nitrogen gas has to be supplied to a container enclosing the reticle R by drawing a vacuum after exchanging reticles. On the other hand, for a container enclosing the illumination optical system IL and the projection optical system PL, the valves V1 to V4, inclusive, may be closed in a state in which it is filled with an ionized nitrogen gas or an ionized nitrogen gas may be supplied in a continual manner. In particular, the continual supply of the ionized nitrogen gas presents the advantages as will be described hereinafter.

Even if contaminating materials would have been removed after the assembly of the illuminating lens unit 2 and the projecting lens unit 4 in the manner as described above, there is the risk that the surfaces of lenses may be contaminated with moisture and so on after the assembly

with the exposure apparatus by causing moisture and so on attached to the inner wall surfaces of the casing 32 and the lens chambers R1 and R2 to be released. However, when the ionized nitrogen gas is supplied continually after the assembly in the manner as described above, each of the lenses is irradiated with ArF light by the exposure operation and the irradiation of such ArF light allows the contaminating materials released from the lens surfaces to be exhausted outside the container together with the nitrogen gas. Therefore, the lens surfaces are not contaminated again with moisture and so on even if they would be released from the inner surfaces thereof. In the embodiment as described above, a description has been made by taking the illuminating lens unit 2 and the projecting lens unit 4, each consisting of plural lenses, as an example, however, it should be noted herein that the present invention can be applied in a like manner to an optical system consisting of reflecting mirrors.

When such an inert gas has been flown continually inside and outside the barrel in the manner as described above, adhesive or filling material used for fixing an optical element such as, for example, a lens, or the like to the barrel (a holding member) of the illumination optical system, the projection optical system or the light sending system in the exposure apparatus is irradiated with radiating beams having an ultraviolet wavelength region and gases consisting of organic materials, etc. derived from the adhesive or filling material, or reaction products, etc.

resulting from such gases may be generated. Even in such a case, this can prevent such gases from attaching to the optical member or entering into the optical path and floating therein. This can also prevent a fluctuation in optical characteristics (e.g., transmittance, reflectance, etc.) of optical members, which may be caused by the irradiation with light beams, or in optical characteristics such as, for example, focal distance, projection magnification, five aberrations of Seidel, telecentricity, etc. in the projection optical system. As a consequence, a fluctuation in the intensity of illuminating light on the mask or substrate can be prevented, so that a pattern of a mask can be transferred onto a substrate always at an appropriate amount of exposing light, and an image of the pattern on the mask can be projected on the substrate always under appropriate imaging conditions.

In addition, the present invention can be applied to the ready implementation of a so-called light cleaning operation for optical members in an exposure apparatus for use in the lithography process for manufacturing micro devices such as semiconductor elements, thin layer magnetic heads, image pickup elements (CCD) and so on, by utilizing the method for the removal of contaminating materials in the manner as described above. The present invention allows contaminating materials attached on the surface of the optical member (e.g., gases derived therefrom or reaction products resulting from such gases, or impurities such as, for example, water or hydrocarbons to be generated

from the inner wall of the barrel, etc.) to be removed simply by irradiating the optical member of the illumination optical system, the projection optical system or the light sending system or otherwise with light beams or illuminating light for exposing, for example, having a wavelength of 185 nm or 254 nm, while the illumination optical system, the projection optical system or the light sending system or otherwise is incorporated into the exposure apparatus.

The optical system to be installed in the exposure apparatus to which the optical device or the cleaning method according to the present invention can be applied may include, for example, an illumination optical system consisting of a plurality of optical elements such as, for example, optical integrators (flyeye lenses) or condenser lenses and illuminating a mask with an exposing light, or a projection optical system (including, for example, a catadioptric optical system) consisting of a plurality of optical elements (refracting elements and/or reflecting elements) arranged along the optical axis thereof and projecting an image of a pattern formed on a mask onto a substrate (such as, for example, a semiconductor wafer, etc.). Moreover, they may include optical systems which comprise, for example, (1) a light sending system having at least one optical element (such as, for example, a movable mirror, parallel flat panel, etc.) for adjusting the position relationship of the optical axis of the illumination optical system with the illuminating light and

leading the illuminating light leaving from a light source disposed on a floor of a clean room separately from the main body of the exposure apparatus; (2) an alignment optical system for detecting the position of an alignment mark on the mask or the substrate by irradiating the mask or the substrate with the illuminating light having an ultraviolet wavelength region; and (3) an optical system of a measurement device for detecting optical characteristics (such as, for example, projection magnification, etc. as described above) of the projection optical system, which is so configured such that a light generating from a mark and passing through the projection optical system is received when a reference mark or a measurement mark on a stage with the mask or the substrate loaded thereon is irradiated with an exposing light or an illuminating light having the wavelength substantially equal to that of the exposing light.

Moreover, when the present invention is applied to the alignment optical system as described above, a fluctuation in the intensity of the illuminating light (an alignment light) to be irradiated on the alignment mark, which may be caused by a fluctuation in the transmittance or reflectance of the optical member, can be prevented. Further, a deterioration in the telecentricity of the illuminating light and so on can also be prevented, which may be caused by a decrease in uniformity of illuminance of the illuminating light on the alignment mark, i.e., by the formation of an irregularity in illuminance, due to the

presence of such gases derived from the adhesive or filling materials used for fixing the optical members to the barrel or such reaction products from such gases, or by a decrease in uniformity of the light intensity in a pupil region of the alignment optical system through which a light flux of the illuminating light focusing on one point on the alignment mark passes. As a consequence, the mask can be aligned with the substrate at a high degree of precision without causing any decrease in precision of detecting the position of the alignment mark.

In addition, when the present invention is applied to the measurement optical system, like the alignment optical system, there can be prevented a fluctuation in the intensity of the illuminating light on the mark due to a fluctuation in the transmittance or reflectance of the optical member, as well as an irregularity of illuminance and a decrease in telecentricity. As a result, the optical characteristics of the projection optical system can be detected at a high degree of precision.

It can also be noted herein that the present invention can further be applied to an exposure apparatus which uses F_2 laser having a wavelength of 157 nm as an exposing light source. In other words, the present invention is effective for a vacuum ultraviolet light (VUV light) having a wavelength region of 100 nm to 200 nm, particularly for a VUV light having a wavelength region of 150 nm to 200 nm. This is because a light having a wavelength region shorter than 150 nm may be likely to

undergo the limitations to a large extent from a glass material, a coating material, and so on.

It can now be noted herein that the terms as referred to in the embodiments as described above correspond to the elements as used in the Claims section of the specification of this application as will be referred to herein. In the embodiments of the present invention as described above, the reticle R corresponds to a mask as referred to so in the Claims section of the specification; the illuminating lens unit 2 and projecting lens units 4 and 4' to an optical lens device; caps 33 and 34 each to a protective filter; tubular path L12 to a supply passage; and the valve V12 to a movable member. It is further to be noted herein that the term "inert gas" referred to in this specification should be understood to include nitrogen gas.

As described above, the present invention can offer the effects as will be described hereinafter.

As the protective filer defining a predetermined space is provided between both ends of each of the plural optical elements, and not only each of the spaces between the optical element and the protective filter but also each of the chambers disposed between the plural optical elements are filled with an inert gas, each of the chambers and the spaces can be purged and cleaned with the inert gas after the assembly of a single body of the optical device, thereby assembling the optical device with the projection exposure apparatus in a state in which the optical elements located on the both sides are not contaminated.

Further, as the optical device is assembled while the space interposed between the protective filter and the optical elements disposed on the both sides thereof is purged with such an inert gas, the optical elements or the protective filter can be prevented from contamination at the time of assembly.

Moreover, in accordance with the present invention, the protective filter is detached while the space interposed between the protective filter and the optical elements on the both sides thereof and a pre-cleaned protective filter is then mounted thereon, so that the optical elements or the protective filter can be prevented from contamination at the time of assembly.

An adsorbing material is mounted on an inner face of the supply passage of the inert gas and the barrel, so that a contaminating material in the inert gas supplied, if it is present therein, can be adsorbed on the absorbing material, and there can be avoided the risk that the surface of the lens or the reflecting mirror is contaminated.

In addition, a filter is disposed on the side downstream of the movable member such as an electromagnetic valve, so that a contamination of the surface of the lens and the surface of the reflecting mirror with the contaminating material generating from the movable member can be prevented.

Furthermore, the contaminating materials can be removed for sure because each of the chambers among the

plural optical elements is so arranged that it can be purged individually with the inert gas.

Moreover, the plural chambers interposed each between the plural optical elements are divided into at least two groups, each group containing a predetermined number of chambers, and each group can be arranged so as to be purged with an inert gas. Therefore, a number of valves for controlling the passage of a gas can be minimized, so that this construction can contribute to a reduction in costs for manufacturing the optical device as a whole.

Also, the contaminating materials attached to the optical elements can be caused to be afloat by the irradiation with the illuminating light after the optical device has been filled with the inert gas, and then the inert gas, together with the floating contaminating materials, can be discharged from the optical device. Therefore, the contaminating materials attached to the surface of each optical element can be removed in such a state that the optical device is assembled as a single body.

In accordance with the present invention, a pre-cleaned optical device can be assembled with the projection exposure apparatus as an illumination optical system or a projection optical system, so that a decrease in transmittance for the lenses or in reflectance for a reflecting mirror can be controlled even immediately after assembly.

Further, the present invention can prevent the optical system such as the projection optical system, the light sending system, and so on from being contaminated, so

that a fluctuation in the optical characteristics of the optical system such as the projection optical system, the light sending system, and so on can be controlled, and projection exposure at a high degree of precision can be implemented.

CLAIMS

1. An optical device comprising:

a protective filter interposed at both ends of a barrel with plural optical elements disposed therein and located apart in a predetermined distance between optical elements disposed on both end sides thereof in the axial direction of the barrel, among the plural optical elements;

wherein an inert gas is filled in advance in a chamber between the plural optical elements and a space between the optical elements on both end sides thereof and the protective filter.

2. The optical device as claimed in claim 1, wherein:

the optical device is installed in an apparatus for irradiating a mask with an illuminating light and exposing a substrate to the illuminating light through the mask; and

the inert gas is an inert gas having a low degree of capability of absorbing the illuminating light.

3. The optical device as claimed in claim 2, wherein the illuminating light has a wavelength of 350 nm or less.

4. The optical device as claimed in claim 2 or 3, wherein:

upon mounting the optical device on a light passage housing of an illumination optical system disposed in the exposure apparatus, the protective filter is detached while purging the space with the gas; and

the light passage housing is then filled with the gas.

5. The optical device as claimed in claim 2 or 3, wherein:

upon mounting the optical device on a light passage housing of an illumination optical system of the exposure apparatus, the protective filter is detached while purging the space with the gas;

another protective filter pre-cleaned is mounted at both ends in the axial direction of the barrel; and

the light passage housing is then filled with the gas.

6. The optical device as claimed in claim 2, wherein:

the exposure apparatus is further provided with a stage system to transfer the mask relatively to the illuminating light and to transfer the substrate relatively to a projection optical system of the exposure apparatus.

7. The optical device as claimed in claim 2, further comprising:

an illuminating light source for the illuminating light disposed separately from the projection exposure apparatus; and

a light sending system having at least one optical element for leading the illuminating light leaving from the illuminating light source to an illumination optical system disposed in the projection exposure apparatus and for adjusting a position relationship between an optical axis of the illumination optical system and the illuminating light;

wherein the light sending system is disposed in a barrel which is filled with a gas having a lower capability of absorbing the illuminating light.

8. An optical device, comprising:

a supply passage which supplies an inert gas into a barrel with plural optical elements disposed therein;

a supply inlet connected to the supply passage;

an exhaust outlet which discharges the inert gas in the barrel; and

a removing member which removes a contaminating material, and which is disposed on an inner wall of the supply passage.

9. The optical device as claimed in claim 8, wherein:

the optical device is installed in an apparatus for irradiating a mask with an illuminating light and exposing a substrate to the illuminating light through the mask; and

the inert gas is a gas having a lower capability of absorbing the illuminating light.

10. The optical device as claimed in claim 9, wherein:

the illuminating light has a wavelength of 350 nm or less.

11. The optical device as claimed in claim 9 or 10, wherein:

the exposure apparatus further comprises an illumination optical system for irradiating the mask with the illuminating light and a projection optical system for projecting the illuminating light leaving from the mask onto the substrate; and

the optical device is installed at least at a portion of the illumination optical system and the projection optical system.

12. The optical device as claimed in claim 11, wherein:

the exposure apparatus is further provided with a stage system to transfer the mask relatively to the illuminating light and to transfer the substrate relatively to a projection optical system of the exposure apparatus, in synchronization with the transfer of the mask.

13. The optical device as claimed in claim 11, wherein:

the exposure apparatus further comprises a light sending system interposed between a light source for emitting the illuminating light and the illumination optical system; and

the light sending system is disposed in a housing which is filled with a gas having a lower capability of absorbing the illuminating light.

14. The optical device as claimed in claim 13, wherein:

the light source is disposed separately from the exposure apparatus; and

the light sending system has an optical element for adjusting a position relationship between an optical axis of the illumination optical system and the illuminating light leaving from the light source.

15. The optical device as claimed in any one of claims 8 to 10, further comprising:

a movable member disposed in the supply passage;

wherein the removing member comprises an adsorbing member or a filter.

16. An optical device installed in an exposure apparatus for transferring a pattern on a mask onto a substrate, wherein:

the optical device is provided with a removing member for removing a contaminating material on an inner surface of a barrel with plural optical elements disposed therein.

17. The optical device as claimed in claim 16, wherein:

the exposure apparatus comprises a projection optical system for projecting an image of the pattern onto the substrate.

18. An optical device for use with an exposure apparatus for irradiating a mask with an illuminating light and transferring a pattern on the mask onto a substrate, wherein:

the optical device has plural chambers formed between plural optical elements disposed in a barrel, each chamber being provided with a gas supply inlet and a gas discharge outlet for a gas having a lower capability of absorbing the illuminating light; and the gas supply inlet and the gas discharge outlet being each provided with an opening-closing valve.

19. The optical device as claimed in claim 18, wherein:

the exposure apparatus has a projection optical system interposed between the mask and the substrate in order to form an image of the pattern on the substrate.

20. The optical device as claimed in claim 18 or 19, wherein:

the plural chambers formed between plural optical elements disposed in the barrel are divided into at least two groups, each group having a predetermined number of chambers; each group being provided with a gas supply inlet

and a gas discharge outlet; and the gas supply inlet and the gas discharge outlet being each provided with an opening-closing valve.

21. A method for cleaning an optical device for use with an exposure apparatus for irradiating a mask with an illuminating light and transferring a pattern on the mask onto a substrate, wherein the optical device has plural chambers formed between plural optical elements disposed in a barrel, each chamber being provided with a gas supply inlet and a gas discharge outlet for a gas having a lower capability of absorbing the illuminating light; and the gas supply inlet and the gas discharge outlet being each provided with an opening-closing valve; said method is characterized by the steps of:

filling the barrel with the gas to a predetermined level of pressure in a state in which the opening-closing valve for the gas supply inlet is opened while the opening-closing valve for the gas discharge outlet is closed;

allowing a contaminating material attached to a surface of each of the optical elements to become suspended or afloat by irradiation with the illuminating light in a state in which the opening-closing valves of the gas supply inlet and the gas discharge outlet are closed;

flowing the gas outside and inside the barrel by opening the opening-closing valve of the gas supply inlet and the opening-closing valve of the gas discharge outlet; and

closing the opening-closing valves of the gas supply

inlet and the gas discharge outlet.

22. The cleaning method as claimed in claim 21, wherein:

the gas flows in each of the plural chambers, prior to closing the opening-closing valve of the gas discharge outlet, in a state in which the opening-closing valve of the gas supply inlet and the opening-closing valve of the gas discharge outlet are both opened.

23. The cleaning method as claimed in claim 21, wherein:

the optical device is configured such that the plural chambers are divided into at least two groups, each group having a predetermined number of chambers; each group being provided with a gas supply inlet and a gas discharge outlet; and the gas supply inlet and the gas discharge outlet being each provided with the opening-closing valve.

24. A projection exposure apparatus for irradiating a mask with an illuminating light and transferring a pattern on the mask onto a substrate through a projection optical system, comprising:

an optical device having plural chambers formed between plural optical elements disposed in a barrel, each chamber being provided with a gas supply inlet and a gas discharge outlet for a gas having a lower capability for absorbing the illuminating light, and the gas supply inlet and the gas discharge outlet being each provided with an opening-closing valve; wherein:

the optical device is cleaned by a cleaning method characterized by the steps of:

filling the barrel with the gas to a predetermined

level of pressure in a state in which the opening-closing valve for the gas supply inlet is opened while the opening-closing valve for the gas discharge outlet is closed;

allowing a contaminating material attached to a surface of each of the optical elements to become suspended or afloat by irradiation with the illuminating light in a state in which the opening-closing valves of the gas supply inlet and the gas discharge outlet are closed;

flowing the gas outside and inside the barrel by opening the opening-closing valve of the gas supply inlet and the opening-closing valve of the gas discharge outlet; and

closing the opening-closing valves of the gas supply inlet and the gas discharge outlet.

25. The projection exposure apparatus as claimed in claim 24, wherein:

the optical device is used as the projection optical system and/or an illumination optical system for irradiating the mask with the illuminating light.

26. The projection exposure apparatus as claimed in claim 24, further comprising:

a stage system for transferring the mask relatively to the illuminating light and for transferring the substrate relatively to the illuminating light leaving from the projection optical system, in synchronization with the transfer of the mask.

27. The projection exposure apparatus as claimed in claim 24, further comprising:

a light sending system disposed between a light source for emitting the illuminating light and an illumination optical system for irradiating the mask with the illuminating light, the light sending system being disposed in a housing having a lower capability of absorbing the illuminating light.

28. The projection exposure apparatus as claimed in claim 27, wherein:

the light source is disposed separately from the projection optical system; and

the light sending system has an optical element for adjusting a position relationship between an optical axis of the illumination optical system and the illuminating light leaving from the light source.

29. The projection exposure apparatus as claimed in claim 24, wherein:

the optical device is configured such that the plural chambers are divided into at least two groups, each group having a predetermined number of chambers and being provided with a gas supply inlet and a gas discharge outlet for the gas, and the gas supply inlet and the gas discharge outlet being each provided with an opening-closing valve.

30. An exposure apparatus for transferring a pattern of a mask onto a substrate, comprising:

an optical system interposed between a light source for emitting an illuminating beam and the substrate; and

an optical unit having a protective filter disposed at least at an end of a barrel holding an optical element

and having the barrel filled with a gas having a lower capability of absorbing the illuminating beam, the optical unit being disposed in the optical system.

31. The exposure apparatus as claimed in claim 30, wherein:

the optical system includes an illumination optical system for irradiating the mask with the illuminating light; and

the optical unit is disposed in the illumination optical system.

32. The exposure apparatus as claimed in claim 30 or 31, wherein the protective filter is detached from the barrel or replaced with another protective filter upon mounting the optical unit on the optical system.

33. The exposure apparatus as claimed in any one of claims 30 to 32, further comprising:

a gas supply device for supplying a gas having a lower capability of absorbing the illuminating light to the optical system;

wherein the gas supply device is operated after the illuminating beam has been irradiated in a state in which the optical system is filled with the gas.

34. The exposure apparatus as claimed in claim 33, further comprising:

an exhaust device for exhausting a gas in the optical system;

wherein the exhaust device is operated before the optical system is filled or supplied with the gas.

35. An exposure apparatus for transferring a pattern of a mask onto a substrate, comprising:

an optical system interposed between a light source for emitting an illuminating beam and the substrate;

a gas supply device which supplies a gas having a lower capability of absorbing the illuminating beam to at least a portion of the optical system; and

an exhaust device which exhausts the gas from the at least the portion of the optical system prior to a supply of the gas.

36. The exposure apparatus as claimed in claim 35, wherein:

the optical system comprises an illumination optical system for irradiating the mask with the illuminating beam, a light sending system interposed between the light source and the illumination optical system, and a projection optical system for projecting the illuminating beam leaving from the mask onto the substrate.

37. The exposure apparatus as claimed in claim 35 or 36, wherein:

the exhaust device and the gas supply device are operated one after another after subjecting the optical system to light cleaning by irradiation with the illuminating beam.

38. The exposure apparatus as claimed in claim 30 or 35, wherein the illuminating beam has a wavelength ranging from 100 to 200 nm.

39. The exposure apparatus as claimed in claim 38,

wherein:

the illuminating beam is ArF excimer laser or F_2 laser; and

the gas is nitrogen or helium.

40. A method for manufacturing an apparatus for exposing a substrate to an illuminating beam through a mask, comprising:

filling a barrel for holding an optical element with a gas having a lower capability of absorbing the illuminating beam, the barrel being provided with a protective filter at least at an end thereof; and

interposing the barrel between a light source for emitting the illuminating beam and the substrate.

41. The method for manufacturing the exposure apparatus as claimed in claim 40, wherein:

the protective filter is detached or replaced with another protective filter after the barrel has been disposed.

42. A method for manufacturing an apparatus for exposing a substrate to an illuminating beam through a mask, said method is characterized by the steps of:

irradiating at least a portion of an optical system with a cleaning light, through which optical system the illuminating beam passes; and

replacing the gas in the optical system with a gas having a lower capability of absorbing the illuminating beam.

43. The method for manufacturing the exposure apparatus

as claimed in claim 42, wherein:

the gas in the optical system is exhausted therefrom before a gas having a lower capability of absorbing the illuminating beam is supplied to the optical system.

44. The method for manufacturing the exposure apparatus as claimed in claim 42 or 43, wherein:

the gas having a lower capability of absorbing the illuminating beam is supplied to the optical system before irradiation with the cleaning light.

45. The method for manufacturing the exposure apparatus as claimed in any one of claims 42 to 44, wherein:

the cleaning light comprises the illuminating beam; and

the optical system comprises an illumination optical system for irradiating the mask with the illuminating beam, and a projection optical system for projecting the illuminating beam leaving from the mask onto the substrate.

ABSTRACT

A reticle (R) is irradiated with an ArF excimer laser beam to transfer a pattern on the reticle (R) onto a wafer (W) through a projection optical system (PL). Each of a plurality of illuminating lens units (2) arranged in the illuminating optical passage has a barrel containing a plurality of lenses, and caps are so provided as to be spaced from the lenses at both ends. Lens chambers among the lenses are filled with an inert gas, and the spaces between the caps and the lenses are also filled with an inert gas. When the illuminating lens unit (2) are housed in and illuminating optical path housing, the caps are removed while purging the spaces. Therefore, the lenses at both ends are prevented from being contaminated and the transmittance of the optical lens device for exposure with light having a wavelength of shorter than 300 nm is prevented from lowering.